FIFTY-FIRST ANNUAL REPORT

OF THE

SECRETARY

OF THE

STATE BOARD OF AGRICULTURE

OF THE

STATE OF MICHIGAN

AND

TWENTY-FIFTH ANNUAL REPORT

OF THE

EXPERIMENT STATION

FROM

JULY 1, 1911, TO JUNE 30, 1912.

BY AUTHORITY

LANSING, MICHIGAN
WYNKOOP HALLENBECK CRAWFORD CO., STATE PRINTERS
1912

REPORT OF THE SECRETARY

OF THE

STATE BOARD OF AGRICULTURE

East Lansing, Mich., *July 1, 1912.*

To Hon. Chase S. Osborn,

Governor of the State of Michigan:

Sir—I have the honor to submit to you herewith, as required by law, the accompanying report for the fiscal year ending June 30, 1912, with supplementary papers.

Very respectfully,

ADDISON M. BROWN,

Secretary of the State Board of Agriculture.

STATE BOARD OF AGRICULTURE

	Term expires.
ROBERT D. GRAHAM, Grand Rapids	1st Monday January, 1914
CHAIRMAN OF THE BOARD.	
ALFRED J. DOHERTY, Clare	1st Monday January, 1914
WILLIAM H. WALLACE, Saginaw	1st Monday January, 1916
I. ROY WATERBURY, Detroit	1st Monday January, 1916
JOHN W. BEAUMONT, Detroit	1st Monday January, 1918
JASON WOODMAN, Paw Paw	1st Monday January, 1918
LUTHER L. WRIGHT, SUPT. OF PUBLIC INSTRUCTION,	*Ex-Officio*
JONATHAN L. SNYDER, PRESIDENT OF THE COLLEGE,	*Ex-Officio.*

ADDISON M. BROWN, East Lansing, Secretary.
BENJAMIN F. DAVIS, Lansing, Treasurer.

STANDING COMMITTEES.

DIVISIONS OF AGRICULTURE AND OF VETERINARY SCIENCE	I. R. Waterbury, R. D. Graham.
DIVISION OF ENGINEERING	A. J. Doherty, J. W. Beaumont.
DIVISION OF HOME ECONOMICS	Jason Woodman, I. R. Waterbury.
DIVISION OF SCIENCE AND LETTERS	J. W. Beaumont, W. H. Wallace.
EXPERIMENT STATION	W. H. Wallace, A. J. Doherty.
EMPLOYEES	R. D. Graham, J. W. Beaumont.
FINANCE	R. D. Graham, W. H. Wallace.
FARMERS' INSTITUTES	A. J. Doherty, Jason Woodman.
BUILDINGS AND COLLEGE PROPERTY	I. R. Waterbury, Jason Woodman.

MICHIGAN AGRICULTURAL COLLEGE.

(Under Control of the State Board of Agriculture.)

FACULTY AND OTHER OFFICERS.

Jonathan L. Snyder, A. M., Ph. D., LL. D., President; [a,b,c] Feb. 25, '96.

Wm. J. Beal, Ph. D., D. Sc., Emeritus Professor of Botany; [a,b] June 9, '70; [c] June 15, '10.

Frank S. Kedzie, M. S., Ph. D., Professor of Chemistry; [a] Sept. 15, '80; [b,c] Sept. 1, '02.

Levi R. Taft, M. S., Superintendent of Farmers' Institutes and State Inspector of Orchards and Nurseries; [a] Aug. 1, '88; [b,c] July 1, '02.

Warren Babcock, B. S., Professor of Mathematics; [a,b] June 30, '91; [c] July 1, '09.

Wilbur O. Hedrick, M. S., Ph. D., Professor of History and Economics; [a,b] Aug. 24, '91; [c] June 20, '06.

Herman K. Vedder, C. E., Professor of Civil Engineering; [a,b] Sept. 15, '91; [c] July 7, '09.

Walter B. Barrows, B. S., Professor of Zoology and Physiology and Curator of the General Museum; [a,b,c] Feb. 15, '94.

Charles E. Marshall, Ph. D., Professor of Bacteriology and Hygiene; [a] July 20, '96; [b,c] Sept. 1, '02.

Rufus H. Pettit, B. S. in Agr., Professor of Entomology; [a] Jan. 1, '97; [b,c] Sept. 1, '06.

Joseph A. Jeffery, B. S. A., Professor of Soils and Soil Physics; [a] Sept. 1, '99; [b,c] Aug. 6, '08.

Maude Gilchrist, B. S., A. M., Dean of Home Economics; [a,b,c] Sept. 1, '01.

Addison M. Brown, A. B., Secretary of the College; [a,b,c] June 1, '02.

Robert S. Shaw, B. S. A., Dean of Agriculture; [a,b] Sept. 1, '02; [c] Jan. 15, '08.

Elida Yakeley, Registrar; [a] July 15, '03; [b,c] June 1, '08.

Arthur R. Sawyer, B. S., E. E., Professor of Physics and Electrical Engineering; [a,b,c] April 11, '04.

A. Crosby Anderson, B. S., Professor of Dairy Husbandry; [a] Sept. 1, '05; [b] June 10, '09; [c] June 15, '10.

Thomas C. Blaisdell, Ph. D., Professor of English Literature and Modern Languages; [a,b,c] Sept. 1, '06.

George W. Bissell, M. E., Dean of Engineering and Professor of Mechanical Engineering; [a,b,c] June 18, '07.

J. Fred Baker, M. F., Professor of Forestry and Supervisor of Forest Reserve Lands; [a,b,c] Oct. 1, '07.

Harry J. Eustace, B. S., M. H., Professor of Horticulture; [a b c] Aug. 15, '08.
Victor T. Wilson, M. E., Professor of Drawing and Design; [a b c] Sept. 1, '08.
Walter H. French, M. Pd., Professor of Agricultural Education; [a b c] Sept. 1, '08.
Vernon M. Shoesmith, B. S., Professor of Farm Crops; [a b c] Feb. 14, '09.
Ernst A. Bessey, Ph. D., Professor of Botany; [a b c] June 15, '10.
Agnes Hunt, B. S., Professor of Domestic Science; [a b c] Sept. 1, '10.
Richard P. Lyman, B. S., M. D. V., Dean of Veterinary Science; Professor of Veterinary Medicine; [a b c] Sept. 28, '10.
John F. Macklin, Professor of Physical Culture; Director of Athletics; [a b c] March 8, '11.
Lieut. Anton C. Cron, Professor of Military Science and Tactics; [a b c] Sept. 1, '11.
Edward H. Ryder, M. A., Associate Professor of History and Economics; [a] Sept. 1, '05; [b c] Oct. 21, '09.
Chace Newman, Assistant Professor of Drawing; [a] Sept. 1, '97; [b c] Sept. 1, '07.
E. Sylvester King, Assistant Professor of English; [a] Jan. 1, '00; [b c] Sept. 1, '02.
Jesse J. Myers, B. S., Assistant Professor of Zoology; [a b] Sept. 1, '01; [c] June 26, '07.
Joseph A. Polson, B. S., Assistant Professor of Mechanical Engineering; [a b] Sept. 1, '06; [c] May 7, '08.
Arthur J. Clark, A. B., Assistant Professor of Chemistry; [a b] Sept. 1, '06; [c] June 10, '09.
Wylie B. Wendt, B. C. E., Assistant Professor of Civil Engineering; [a b] Sept. 1, '06; [c] May 26, '09.
W. Lloyd Lodge, B. S., M. A., Assistant Professor of Physics; [a b] Oct. 1, '06; [c] April 28, '09.
F. Hobart Sanford, B. S., Assistant Professor of Forestry; [a b] Dec. 1, '06; [c] May 1, '09.
Charles P. Halligan, B. S., Assistant Professor of Horticulture; [a b] April 8, '07; [c] May 7, '08.
Otto Rahn, Ph. D., Assistant Professor of Bacteriology; [a] Sept. 1, '07; [b c] Sept. 1, '08.
Richard DeZeeuw, Ph. D., Assistant Professor of Botany; [a b] Sept. 1, '09; [c] Sept. 1, '10.
Edward J. Kunze, B. S., M. E., Assistant Professor of Mechanical Engineering; [a b c] Sept. 1, '10.
Frank W. Chamberlain, B. S., D. V. M., Assistant Professor of Veterinary Science, [a b c] Jan. 1, '11.
John S. McDaniel, B. Sc., D. V. S., Assistant Professor of Veterinary Surgery; [a b c] Sept. 1, '11.
Cyrus A. Melick, D. C. E., Assistant Professor of Civil Engineering; [a b c] Sept. 1, '11.
Charles W. Chapman, A. B., B. S., Assistant Professor of Physics; [a b c] Sept. 1, '11.
Ralph C. Huston, M. S., Assistant Professor of Chemistry; [a b c] Sept. 1, '11.

The names of instructors whose resignations took effect between June 30 and Sept. 1, '11, do not appear below.

Thomas Gunson, Instructor in Horticulture and Superintendent of the Grounds; [a b] April 1, '91; [c] Sept. 1, '05.

Caroline L. Holt, Instructor in Drawing; [a b c] Sept. 1, '98.

Louise Freyhofer, B. S., Instructor in Music; [a b c] Sept. 1, '02.

Norma L. Gilchrist, A. B., Instructor in English and German; [a b c] Sept. 1, '05.

L. Zae Northrup, B. S., Instructor in Bacteriology; [a b c] Sept. 1, '07.

Mrs. Minnie A. W. Hendrick, A. B., Instructor in History and Economics; [a] Sept. 1, '07; [b c] Sept. 1, '08.

William A. Robinson, A. B., S. T. B., Instructor in English; [a b c] Sept. 1, '07.

Rose M. Taylor, A. B., Instructor in Botany; [a b c] Feb. 8, '08.

Ward Giltner, D. V. M., M. S., Instructor in Veterinary Science; [a b c] July 1, '08.

George D. Shafer, Ph. D., Instructor in Entomology; [a] July 1, '08; [b c] Sept. 1, '11.

Herman Hensel, A. B., Instructor in German and English; [a b c] Sept. 1, '08.

Helen I. Michaelides, Instructor in French and English; [a b c] Sept. 1, '08.

Isabel P. Snelgrove, Instructor in Drawing; [a b c] Sept. 1, '08.

George A. Brown, B. S., Instructor in Animal Husbandry; [a b c] Sept. 1, '08.

Mrs. Lillian L. Peppard, Instructor in Domestic Art and Domestic Science; [a b c] Sept. 1, '08.

William E. Laycock, Instructor in Physics; [a b c] Sept. 1, '08.

Antoinette A. Robson, Instructor in German and English; [a b c] Jan. 1, '09.

Herbert E. Marsh, B. S., Instructor in Civil Engineering; [a b] Jan. 1, '09; [c] Sept. 1, '10.

Benjamin B. Roseboom, Jr., B. S., Instructor in Zoology; [a b c] Jan. 15, '09.

A. Watt, Instructor in Blacksmithing; [a b c] April 1, '09.

Maurice F. Johnson, B. S., Instructor in Mathematics; [a b c] April 1, '09.

Chas. H. Spurway, B. S., Instructor in Soil Physics; [a b c] Sept. 1, '09.

Harry H. Musselman, B. S., Instructor in Farm Mechanics; [a b c] Sept. 1, '09.

*John Bowditch, Jr., Instructor in Animal Husbandry; [a b c] Sept. 1, '09.

George A. Kelsall, B. S., Instructor in Electrical Engineering; [a b c] Sept. 1, '09.

Stanley E. Crowe, B. A., Instructor in Mathematics; [a b c] Sept. 1, '09.

James E. Robertson, B. S., Instructor in Mathematics; [a b c] Sept. 1, '09.

Ernest E. Beighle, B. S., Instructor in Mathematics; [a b c] Sept. 1, '09.

Lloyd C. Emmons, B. S., A. B., Instructor in Mathematics; [a b c] Sept. 1, '09.

Karl E. Hopphan, B. S., Instructor in Mathematics; [a b c] Sept. 1, '09.

Hugh A. Snepp, B. S., Instructor in Mathematics; [a b c] Sept. 1, '09.

Frederick A. Burt, B. S., Instructor in Zoology; [a b c] Sept. 1, '09.

Harold S. Osler, B. S., Instructor in Zoology; [a b c] Sept. 1, '09.

Richard H. Reece, B. S., Instructor in Mathematics; a b c Jan. 1, '10.
Dewey A. Seeley, B. S., Instructor in Meteorology; a b c March 16, '10.
Eugenia I. McDaniel, A. B., Instructor in Entomology; a b c April 1, '10.
Serg. P. J. Cross, Instructor in Military Science and Tactics; a b c May 1, '10.
Ruth F. Allen, Ph. D., Instructor in Botany; a b c Sept. 1, '10.
Andrew M. Ockerblad, B. S., in C. E., Instructor in Civil Engineering; a b c Sept. 1, '10.
Ernest A. Evans, Instructor in Mechanical Engineering; a b c Sept. 1, '10.
Max D. Farmer, B. S., Instructor in Drawing; a b c Sept. 1, '10.
Ernst G. Fischer, Ph. B., Instructor in German; a b c Sept. 1, '10.
Grace L. Scott, Instructor in Music; a b c Sept. 1, '10.
Bertha E. Thompson, A. B., Instructor in Botany; a b c Sept. 1, '10.
Grace E. Stevens, A. B., Instructor in Domestic Science; a b c Sept. 1, '10.
Raymond D. Penney, Instructor in English; a b c Sept. 1, '10.
Louis B. Mayne, A. B., Instructor in English; a b c Sept. 1, '10.
James L. Morse, Instructor in Mechanical Engineering; a b c Sept. 1, '10.
Arthur S. Smith, Instructor in Mechanical Engineering; a b c Sept. 1, '10.
Fred Killeen, Director of M. A. C. Chorus; a b c Sept. 1, '10.
Oren L. Snow, B. S., Instructor in Physics; a b c Sept. 1, '10.
*William H. Brown, Ph. D., Instructor in Plant Physiology; a b c Nov. 12, '10.
George H. Coons, A. M., Instructor in Plant Pathology; a b c Jan. 1, '11.
W. Irving Gilson, B. S., Instructor in Forestry; a b c Jan. 1, '11.
Floyd E. Fogle, Instructor in Farm Mechanics; a b c March 8, '11.
George W. Hobbs, B. S., Instructor in Mechanical Engineering; a b c Sept. 1, '11.
Roy G. Hoopingarner, B. S., Instructor in Farm Crops; a b c Sept. 1, '11.
Harold W. F. Newhall, B. S. A., Instructor in Dairying; a b c Sept. 1, '11.
Frederick W. Bentzen, B. S., Instructor in Chemistry; a b c Sept. 1, '11.
Rachel M. Benham, B. S., Instructor in Bacteriology; a b c Sept. 1, '11.
Ralph W. Powell, B. S., Instructor in Civil Engineering; a b c Sept. 1, '11.
Edward D. Kingman, Ph. B., Instructor in Civil Engineering; a b c Sept. 1, '11.
John R. Mitchell, A. B., Instructor in Chemistry; a b c Sept. 1, '11.
Harold H. Morris, B. A., Instructor in Chemistry; a b c Sept. 1, '11.
Joseph C. Bock, Ch. E., Instructor in Chemistry; a b c Sept. 1, '11.
Walton S. Bittner, B. A., Instructor in English and German; a b c Sept. 1, '11.
Edith W. Casho, Instructor in Physical Culture; a b c Sept. 1, '11.
Milton Simpson, M. A., Instructor in English; a b c Sept. 1, '11.
Hazel H. Berg, A. B., B. S., Instructor in Domestic Art; a b c Sept. 1, '11.
Royal E. Davis, A. B., Instructor in Zoology; a b c Sept. 1, '11.
Rufus P. Hibbard, Ph. D., Instructor in Plant Physiology; a b c Sept. 1, '11.
John O. Linton, B. S., Instructor in Poultry Husbandry; a b c Sept. 1, '11.

Bruce E. Hartsuch, A. B., Instructor in Chemistry; [a b c] Sept. 1, '11.
Chas. S. Dunford, M. A., Instructor in Economics; [a b c] Sept. 1, '11.
Chas. D. Curtiss, B. S., Instructor in Civil Engineering; [a b c] Sept. 1, '11.
George W. Hood, B. S., Instructor in Horticulture; [a b c] Sept. 1, '11.
Linda E. Landon, Librarian; [a b c] Aug. 24, '91.
E. C. Baker, Foreman of Foundry; [a b c] Nov. 1, '97.
Lory F. Newell, Engineer; [a b c] Jan. 1, '98.
Benjamin A. Faunce, Clerk to President and Editor M. A. C. Record; [a] Sept. 1, '99; [b c] April 1, '10.
Rowena Ketchum, Nurse in charge of College Hospital; [a b c] Sept. 1, '00.
*Edwyn A. Bowd, College Architect; [a b c] Jan. 1, '02.
Andrew P. Krentel, Foreman of Wood Shop; [a b c] Sept. 1, '02.
Charles W. Brown, B. S., Assistant in Bacteriology; [a b c] Aug. 1, '06.
William R. Holmes, Foreman of Forge Shop; [a b c] Sept. 1, '06.
Jacob Schepers, Cashier; [a b] May 1, '07; [c] July 1, '07.
Ralph S. Hudson, B. S., Farm Foreman; [a b c] Dec. 1, '07.
Maud A. Meech, Chief Clerk to Secretary; [a b] April 1, '08; [c] Sept. 1, '10.
Albert H. Davis, Foreman of the Horticultural Department; [a b c] Sept. 1, '08.
W. F. Raven, Live Stock Field Agent; [a b c] April 1, '09.
O. K. White, B. S., Horticultural Field Agent; [a b c] April 1, '09.
E. C. Crawford, Shop Engineer; [a b c] July 1, '09.
Robert J. Baldwin, B. S., Executive Assistant to Dean of Agriculture; [a] Sept. 1, '09; [b c] Jan. 1, '10.
A. R. Potts, Field Agent Soils and Crops; [a b c] Sept. 9, '09.
Louise E. Walsworth, Clerk to Secretary; [a b c] Jan. 17, '10.
John A. Neal, Assistant in Machine Shop; [a b c] Nov. 14, '10.
Warren S. Robbins, Assistant in Bacteriology; [a b c] April 1, '11.
Elizabeth M. Palm, B. S., Assistant Librarian; [a b c] July 15, '11.
*Luella G. Harper, Clerk to Secretary; [a b c] July 21, '11.
Clara A. Hinman, Bookkeeper; [a b c] Aug. 1, '11.
Blanche A. Birchard, Clerk to President; [a b c] Aug. 10, '11.
Mrs. Harriet B. Crawford, House Director; [a b c] Sept. 1, '11.
Charles D. Betts, Purchasing Agent; [a b c] Sept. 1, '11.
Johannis C. Th. Uphof, in charge of Botanic Garden; [a b c] Feb. 23, '12.
Ethel M. Gilbert, Clerk to Secretary; [a b c] April 25, '12.

EXPERIMENT STATION WORKERS.

Andrew J. Patten, B. S., Chemist; [a b c] Sept. 1, '05.
Frank A. Spragg, M. S., Assistant in Crops (Plant Breeding); [a b c] Dec. 1, '06.
Charles S. Robinson, M. S., Research Assistant in Chemistry; [a b c] Sept. 1, '09.
Myra V. Bogue, Bulletin Clerk; [a b c] Jan. 1, '10.
George J. Bouyoucos, Ph. D., Research Assistant in Soils; [a b c] June 19, '11.
William C. Marti, B. S., Assistant in Chemistry; [a b c] Sept. 1, '11.
F. H. VanSuchtelen, Ph. D., Research Assistant in Bacteriology; [a b c] Sept. 1, '11.

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*Resigned.
a First appointment.
b Present appointment.
c Present title.

AGRICULTURAL EXPERIMENT STATION

OF THE

MICHIGAN AGRICULTURAL COLLEGE

(Under the control of the State Board of Agriculture.)

STATION COUNCIL.

JONATHAN L. SNYDER, A. M., Ph. D., L. L. D. President *Ex-officio.*
ROBERT S. SHAW, B. S. A., Director.
CHARLES E. MARSHALL Ph. D., Scientific and Vice-Director and Bacteriologist.
HARRY J. EUSTACE, B. S., Horticulturist.
J. FRED BAKER, M. F., - Forester.
A. CROSBY ANDERSON, B. S., Dairy Husbandman.
RUFUS H. PETTIT, B. S. A., Entomologist.
ANDREW J. PATTEN, B. S., - Chemist.
JOSEPH A. JEFFERY, B. S. A., Soil Physicist.
ERNST A. BESSEY, Ph D., - Botanist.
VERNON M. SHOESMITH, B. S., Farm Crops Experimenter.
ADDISON M. BROWN - - Secretary.

ADVISORY AND ASSISTANT STAFF.

CHARLES P. HALLIGAN, B. S., Asst. Horticulturist.
OTTO RAHN, Ph. D., Asst. Bacteriologist.
GEORGE A. BROWN, B. S., Asst. Animal Husbandman.
GEORGE D. SHAFER, Ph. D., Asst. Entomologist.
WARD GILTNER, D. V. M. M. S., Research Asst. in Bacteriology.
CHARLES W. BROWN, B. S., Research Asst. in Bacteriology.
W. S. ROBBINS, B. S., Asst. in Bacteriology.
RUFUS P. HIBBARD, Ph. D., Research Asst. in Plant Physiology.
GEO. H. COONS, A. B., A. M., Research Asst. in Plant Pathology.
FRANK A. SPRAGG, M. S., Asst. in Crops (Plant Breeding.)
L ZAE NORTHRUP, B. S., Asst. in Bacteriology.
LINDA E. LANDON, - - Librarian.
CHARLES S. ROBINSON, M. S. Research Asst. in Chemistry.
FRANS H. H. VAN SUCHTELEN, Ph. D., Research Asst. in Bacteriology,
WM. C. MARTI, B. S., Asst. in Chemistry.
EUGENIA I. MCDANIEL, Asst. in Entomology.
GEO. J. BOUYOUCOS, Ph. D., Research Asst. in Soil Physics.
MYRA V. BOGUE - Bulletin Clerk.

STANDING COMMITTEE IN CHARGE.

HON. WILLIAM H. WALLACE - - - - - - - - - - - - - - Saginaw.
HON. ALFRED J. DOHERTY - - - - - - - - - - - - - - - Clare.

STATE WEATHER SERVICE.

(Under the control of the State Board of Agriculture.)

OFFICER OF THE SERVICE.

Director - - - - - - - - - C. F. SCHNEIDER, U. S. Weather Service.

ACCOUNTS OF

THE MICHIGAN AGRICULTURAL COLLEGE

FOR THE YEAR ENDING JUNE 30, 1912.

SECRETARY'S FINANCIAL REPORT.

			Dr.	Cr.
July 1, 1911.	Cash on hand		$3,498 72	
July 1, 1911.	Cash on deposit, College Treasurer		10,722 09	
June 30, 1912.	To special appropriation receipts		55,214 86	
	From State Treasurer	$17,410 00		
	From United States Treasurer	30,000 00		
	From institution and other sources	7,804 86		
June 30, 1912.	By special appropriation disbursements			$60,147 83
June 30, 1912.	To current account receipts		408,192 61	
	From State Treasurer, land grant interest	$70,265 32		
	From State Treasurer, one-tenth mill tax	185,800 00		
	From U. S. Treasurer, Morrill Fund	50,000 00		
	From institution and other sources	99,511 11		
	From South Haven Experiment Station	332 15		
	From U. P. Experiment Station	2,284 03		
	By general account disbursements			400,288 57
	From current account	$377,032 77		
	From supplementary accounts	23,255 80		
June 30, 1912.	By cash on hand			2,475 67
June 30, 1912.	By cash on deposit			14,716 21
			$477,628 28	$477,628 28

TABLE NO. 1.—*Tabular exhibit of Secretary's report.*

	Balance sheet July 1, 1911.		Transactions July 1, 1911, to June 30, 1912.		Balance sheet June 30, 1912.	
	Dr.	Cr.	Dr.	Cr.	Dr.	Cr.
Cash	$3,498 72	....	$1,023 05	....	$2,475 67	....
College Treasurer*	10,722 09			$3,994 12	14,716 21	
Special appropriations	....	$3,937 17	55,214 86	60,147 83	....	$5,350 37
Current accounts	....	10,283 34	405,553 21	377,032 77	....	11,841 51
Supplementary accounts	....	....	2,639 40	23,255 80	....	....
Totals	$14,220 81	$14,220 81	$464,430 52	$464,430 52	$17,191 88	$17,191 88

*Treasurer's statement is greater July 1, 1911 by $7,548.96 and June 30, 1912 by $9,288.58; warrants outstanding.

TREASURER'S ACCOUNT.

	Dr.	Cr.
Balance on July 1, 1911	$18,271 05	
Receipts from State Treasurer, and Secretary of College	463,911 10	
Interest on deposits during year	531 92	
Warrants paid July 1, 1911 to June 30, 1912		$458,709 28
Balance on hand June 30, 1912		24,004 79
Total	$482,714 07	$482,714 07

TABLE NO. 2.—*Statement of special appropriation accounts for fiscal year ending June 30, 1912.*

Name of appropriation.	Balance of accounts, July 1, 1911.		Receipts during fiscal year.		Total available.	Total expended.	Balance of account, June 30, 1912.	
	Dr.	Cr.	From State Treasurer.	From institution and other sources.			Dr.	Cr.
Experiment Station		$1,262 69	*$30,000 00	$5,937 55	$37,200 24	$36,242 33	....	$957 91
Nursery License and Inspection				1,223 75	1,223 75	1,223 75		
Sundry Improvements		2,418 62	5,000 00	607 06	8,025 68	3,647 19		4,378 49
Sayer Fund		50 00		12 50	62 50	50 00	....	12 50
Addition to Chemical Laboratory	....	6,568 59	11,410 00	24 00	18,002 59	18,002 59		
Weather Bureau	$16 56	....	1,000 00	....	983 44	981 97		1 47
Total	$16 56	$10,299 90	$47,410 00	$7,804 86	$65,498 20	$60,147 83	....	$5,350 37

*United States Treasurer.

TABLE NO. 3.—*William Smith Sayer, Scholarship Fund.*

Fund.	Year ending June 30.	Income.	Income expended to	Amount.	Balance including principal.
$500.00 received of F. F. Sayer, administrator of the estate of William Smith Sayer, to establish Scholarship in Bacteriology.......	1910	$32 25	A. McVittie	$19 75	$512 50
	1911	37 50	....	....	550 00
	1912	12 50	D. F. Fisher	25 00	512 50
			H. K. Wright	25 00	
		$82 25		$69 75	

3

TABLE NO. 4.—*Current account, July 1, 1911, to June 30, 1912.*

On account of—	Dr. To disbursements.	Cr. By receipts.
U. S. Treasurer, 22d annual payment under act of Congress of August 1890		$50,000 00
State Treasurer, one-tenth mill fund		185,800 00
State Treasurer, interest on proceeds of sales of U. S. land grant		70,265 32
Advertising	$3,216 21	84 79
Agricultural Education	1,184 83	1 15
Animal Husbandry	7,645 57	4,330 27
Athletics	1,671 38	1,572 55
Bacteriological	11,748 37	14,383 11
Botanical	2,624 08	97 75
Chemical	14,134 19	5,624 18
Civil Engineering	1,683 08	698 20
Cleaning	3,278 55	749 67
College Extension	2,582 76	
Contingent Building	29,603 22	34,388 07
Diploma fees, $865.00; incidentals, $9,052.50; matriculation, $2,435.00; room rent, $10,988.58; tuition, $2,300.00; delinquent, $409.00; sundry, $8,337.99.		
Crops	984 17	92 13
Dairy Husbandry	12,829 55	10,219 30
Dean's Office	1,685 69	5 62
Drawing	629 46	18 25
Electric Lighting	6,482 96	2,395 28
English	471 04	80 00
Entomology	938 20	107 81
Farm and Horses	8,787 33	5,827 92
Forestry	5,041 41	529 24
Freight and Cartage	158 46	
Farm Mechanics	2,255 64	992 25
Graduate School Agriculture	268 22	50 00
Graduate School of Home Economics	86 19	60 00
Heating	30,416 38	539 69
History	154 46	38 00
Horticultural	7,415 95	1,227 22
Home Economics	3,646 54	1,754 40
Library	3,754 28	32 30
Mathematical	89 60	189 00
Mechanical	8,573 74	1,824 73
Meteorology	106 04	35 00
M. A. C. Record	1,210 69	570 50
Military	1,236 77	16 15
Miscellaneous	9,900 34	3,946 92
Office, President's	125 97	
Office, Secretary's	2,185 90	746 91
Physical	2,480 06	613 40
Poultry	2,632 67	1,185 21
Registrar	707 35	
Salaries	170,837 52	1,675 00
Soils	1,096 09	6 15
Special Courses	4,197 26	1,991 00
Telephones	1,104 90	358 48
Veterinary	2,749 93	180 52
Zoological	2,089 77	249 77
Total	$377,032 77	$405,553 21
Supplementary accounts:		
Bulletins	6,998 42	
Farmers' Institutes	8,785 94	23 22
South Haven Experiment Station	2,181 90	332 15
Upper Peninsula Experiment Station	5,289 54	2,284 03
Balance beginning of period July 1, 1911		3,937 47
Balance beginning of period July 1, 1912	11,841 51	
Total	$412,130 08	$412,130 08

TABLE NO. 5. *Experiment Station accounts for fiscal year ending June 30, 1912.*

On account of—	Disbursements. Adams.	Hatch.	State.	Dr. Total disbursements for each dept.	Cr. By receipts.
Balance July 1, 1911	....	....	....	....	$1,262 69
U. S. Treasurer for fiscal year	....	....	....	....	30,000 00
Fertilizer fees	....	....	....	....	5,420 00
Bacteriological Dep't	$1,317 80	$697 04	$71 34	$2,086 18	....
Botanical Dep't	1,068 67	530 20	314 27	1,913 14	31 15
Chemical Dep't	585 19	1,169 28	1,651 39	3,405 86	42 01
Director's office	....	140 71	1,110 03	1,250 74	3 01
Entomological Dep't	241 41	425 29	64 41	731 11	20 00
Farm Dept	....	1,562 45	185 14	1,747 59	169 90
Horticultural Dep't	....	1,081 34	13 17	1,094 51	....
Library	....	771 63	24 33	795 96	4 80
Salaries	11,086 16	8,520 70	2,684 12	22,290 98	....
Office, Secretary's	....	....	68 50	68 50	....
Soil Physicist	700 77	101 36	55 63	857 76	246 65
Balance June 30, 1912	....	....	....	957 91	....
Total	$15,000 00	$15,000 00	$6,242 33	$37,200 24	$37,200 21

TABLE NO. 6.—*Positions and salaries as shown by pay roll dated June 30, 1912.*

Grade.	Rate per year.	Classification.		Other sources.	
		Current.	Experiment station.		
Administration and Miscellaneous					
President's office:					
President	$5,000 00	$5,000 00			House.
Editor M. A. C. Record	1,100 00	1,100 00			
Clerk	600 00	600 00			
Secretary's office:					
Secretary	3,000 00	1,300 00	$700 00	$1,000 00	House.
Cashier	1,500 00	1,300 00	200 00		
Bookkeeper	800 00	700 00	100 00		
Chief Clerk	950 00	825 00	125 00		
Purchasing Agent	1,500 00	1,500 00			
Stenographer	600 00	600 00			
Clerk	600 00	600 00			
Registrar's office:					
Registrar	1,000 00	1,000 00			
Institute and Nursery Inspector:					
Superintendent	2,000 00	2,000 00			House.
Library:					
Librarian	1,000 00	880 00	120 00		Rooms.
Asst. Librarian	600 00	600 00			
Miscellaneous:					
Engineer	1,200 00	1,200 00			
Plumber	900 00	900 00			
Night watchman	600 00	600 00			
Nurse	500 00	500 00			
Leader of Band	250 00	250 00			
Instructor Meteorology	300 00	300 00			
Instructor, Chorus	240 00	240 00			
Stenographer	550 00	550 00			
Stenographer	550 00	550 00			
Stenographer	500 00	500 00			
Stenographer	500 00	500 00			
Stenographer	540 00	540 00			
Stenographer	360 00	360 00			
Division of Home Economics					
Dean	1,700 00	1,700 00			Rooms.
Dept. Domestic Art:					
Instructor	1,000 00	1,000 00			Rooms.
Instructor	800 00	800 00			Rooms.
Dept. Domestic Science:					
Professor	1,400 00	1,400 00			Rooms.
Instructor	700 00	700 00			Rooms.
Instructor Music	1,100 00	1,100 00			
Asst. instructor Music	600 00	600 00			Rooms.
Inst. Physical Culture	600 00	600 00			Rooms.
House Director	550 00	550 00			Rooms.
Division of Engineering					
Dean	3,000 00	3,000 00			House.
Clerk	600 00	600 00			
Dept. of Civil Engineering:					
Professor	2,500 00	2,500 00			House.
Asst. Professor	1,500 00	1,500 00			
Asst. Professor	1,400 00	1,400 00			
Instructor	1,200 00	1,200 00			
Instructor	1,000 00	1,000 00			
Instructor	900 00	900 00			
Instructor	800 00	800 00			
Instructor	750 00	750 00			
Dept. of Drawing and Design:					
Professor	2,300 00	2,300 00			
Asst. professor	1,400 00	1,400 00			
Instructor	850 00	850 00			
Instructor	700 00	700 00			
Instructor	850 00	850 00			

TABLE NO. 6.—*Continued.*

Grade.	Rate per year.	Classification. Current.	Classification. Experiment station.	Other sources.	
Dept. of Mech'l Engineering:					
Asst. professor	$1,800 00	$1,800 00			
Asst. professor	1,500 00	1,500 00			
Instructor	700 00	700 00			
Instructor	720 00	720 00			
Instructor	1,000 00	1,000 00			
Instructor	1,200 00	1,200 00			
Instructor	900 00	900 00			
Foreman wood shop	900 00	900 00			
Foreman foundry	900 00	900 00			
Foreman forge shop	900 00	900 00			
Shop Engineer	780 00	780 00			
Dept. of Physical and Elec. Eng:					
Professor	2,300 00	2,300 00			
Asst. professor	1,500 00	1,500 00			
Asst. professor	1,300 00	1,300 00			
Instructor	1,100 00	1,100 00			
Instructor	1,100 00	1,100 00			
Instructor	850 00	850 00			
Division of Science and Letters					
Dept of Bacteriology:					
Professor	3,000 00	2,000 00	$1,000 00		
Asst. Professor	1,800 00	1,350 00	450 00		
Asst. Bacteriologist	1,350 00	250 00	1,100 00		
Instructor	700 00	700 00			
Asst. in Bacteriology	900 00	300 00	600 00		
Asst. in Bacteriology	1,200 00	600 00	600 00		
Research Asst in Bacteriology	1,700 00	850 00	850 00		
Research Asst. in Bacteriology	1,200 00		1,200 00		
Dept. of Botany:					
Professor	2,000 00	1,800 00	200 00		House.
Asst. Professor	1,400 00	1,400 00			
Instructor	950 00	950 00			
Instructor	850 00	850 00			
Instructor	850 00	850 00			
Instructor	720 00	720 00			
Asst. in botany	1,200 00	300 00	900 00		
Asst. in botany	1,200 00	300 00	900 00		
Dept. of Chemistry:					
Professor	3,000 00	3,000 00			
Asst. Professor	1,400 00	1,400 00			
Asst. Professor	1,250 00	1,250 00			
Instructor	1,000 00	1,000 00			
Instructor	850 00	850 00			
Instructor	850 00	850 00			
Instructor	750 00	750 00			
Instructor	750 00	750 00			
Dept. of English:					
Professor	2,000 00	2,000 00			House.
Asst. Professor	1,400 00	1,400 00			
Instructor	800 00	800 00			
Instructor	800 00	800 00			
Instructor	1,100 00	1,100 00			
Instructor	800 00	800 00			
Instructor	900 00	900 00			
Instructor	900 00	900 00			
Instructor	1,000 00	1,000 00			
Instructor	900 00	900 00			
Instructor	950 00	950 00			
Instructor	1,000 00	1,000 00			
Dept. of Entomology:					
Professor	2,000 00	1,200 00	800 00		House.
Instructor	850 00	500 00	350 00		
Research Asst. in Entomology	1,800 00	300 00	1,500 00		
Dept. of History:					
Professor	2,300 00	2,300 00			
Asst. Professor	1,700 00	1,700 00			
Instructor	850 00	850 00			
Instructor	900 00	900 00			

TABLE NO. 6.—*Continued.*

Grade.	Rate per year.	Classification. Current.	Classification. Experiment station.	Other sources.
Dept. of Military Science:				
Sargeant	$700 00	$700 00		
Dept. of Mathematics:				
Professor	2,300 00	2,300 00		
Instructor	900 00	900 00		
Instructor	1,000 00	1,000 00		
Instructor	1,000 00	1,000 00		
Instructor	1,300 00	1,300 00		
Instructor	1,000 00	1,000 00		
Instructor	900 00	900 00		
Instructor	1,000 00	1,000 00		
Instructor	900 00	900 00		
Dept. of Physical Culture:				
Director	2,000 00	2,000 00		
Dept. of Zoology:				
Professor	2,000 00	2,000 00		House.
Asst. Professor	1,500 00	1,500 00		
Instructor	900 00	900 00		
Instructor	1,000 00	1,000 00		
Instructor	750 00	750 00		
Instructor	900 00	900 00		
Division of Veterinary Science				
Professor	2,500 00	2,500 00		
Asst. Professor	1,600 00	1,600 00		
Asst. Professor	1,600 00	1,600 00		
Division of Agriculture				
Dean	3,000 00	2,000 00	$1,000 00	House.
Clerk	1,000 00	500 00	500 00	
Dept. of Animal Husbandry:				
Instructor	1,300 00	1,100 00	200 00	
Dept. of Dairy Husbandry:				
Professor	2,000 00	1,800 00	200 00	
Instructor	1,000 00	1,000 00		
Clerk	480 00	480 00		
Dept. of Poultry:				
Instructor	1,000 00	1,000 00		
Dept. of Farm Crops:				
Professor	2,200 00	2,000 00	200 00	
Instructor	1,000 00	1,000 00		
Asst. to Farm Crops Exper'r.	1,350 00		1,350 00	
Dept. of Soils:				
Professor	2,300 00	2,100 00	200 00	
Instructor	1,150 00	1,150 00		
Research Asst. in Soil Physics	1,200 00		1,200 00	
Dept. of Farm Mechanics:				
Instructor	1,300 00	1,300 00		
Asst. Instructor	750 00	750 00		
Instructor	800 00	800 00		
Dept. of College Extension:				
Field agent live stock	1,500 00	1,500 00		
Field agent farm crops	800 00	800 00		
Field agent horticulture	1,500 00	1,500 00		
Field agent forestry	1,500 00	1,500 00		
Dept. of Farm and Horses:				
Foreman College Farm	900 00	900 00		House.
Dept. of Agrl. Education:				
Professor	2,300 00	2,300 00		

TABLE NO. 6.—*Concluded.*

Grade.	Rate per year.	Classification.		Other sources.	
		Current	Experiment station.		
Dept. of Forestry:					
Professor	$2,300 00	$2,100 00	$200 00	....	....
Asst. Professor	1,600 00	1,600 00	....	....	....
Instructor	1,500 00	1,500 00	....	....	....
Dept. of Horticulture:					
Professor	2,000 00	1,800 00	200 00	....	House.
Asst. Professor	1,700 00	1,500 00	200 00	....	....
Instructor	1,200 00	1,200 00	....	....	House.
Instructor	1,000 00	1,000 00	....	....	....
Foreman on grounds	600 00	600 00	....	....	House.
Chem. Div. Exp. Station:					
Chemist	2,000 00	....	2,000 00	....	....
Research Asst. in Chemistry	1,350 00	....	1,350 00	....	....
Asst. in Chemistry	1,000 00	....	1,000 00	....	....
Bulletin Clerk	600 00	....	600 00	....	....
Total	$201,640 00	$178,545 00	$22,095 00	$1,000 00	....

TABLE NO. 7.—*Income of the Michigan Agricultural College from all outside sources from the date of its foundation to the present time.*

Year.	From State Legislature.			From U. S. Congress.			Total.
	For current expenses.	For special purposes.	Land sales, salt springs and swamp land grants.	Morrill act of 1862, interest from land grant and trespass.	Hatch act of 1887, and Adams act of 1906, experiment station.	Morrill act of 1890, supplementary endowment.	
1855			$56,320 00				$56,320 00
1856							
1857	$40,000 00						40,000 00
1858							
1859	37,500 00						37,500 00
1860							
1861	6,500 00		152 25				6,652 25
1862	10,000 00		218 97				10,218 97
1863	9,000 00		407 80				9,407 80
1864	9,000 00		726 09				9,726 09
1865	15,000 00		1,156 61				16,156 61
1866	15,000 00		1,094 27				16,094 27
1867	20,000 00		7,608 38				27,608 38
1868	20,000 00		592 49				20,592 49
1869	20,000 00	$30,000 00	17,559 00	$58 96			67,617 96
1870	20,000 00		1,320 02	2,720 93			24,040 95
1871	18,250 00	10,500 00	4,135 72	3,785 54			36,671 26
1872	18,250 00	3,000 00	217 05	7,175 65			28,642 70
1873	21,796 00	15,602 00	10 13	11,059 06			48,467 19
1874	13,000 00	15,602 00	150 13	14,061 98			42,814 11
1875	7,638 00	7,755 50	144 53	14,446 14			29,984 17
1876	7,638 00	6,755 50	1,773 09	16,830 17			32,996 76
1877	6,150 00	30,686 80	979 06	15,172 86			52,988 72
1878	6,150 00	5,686 80	826 60	15,807 09			28,470 49
1879	4,971 80	16,068 32	712 22	16,978 22			38,730 56
1880	4,971 80	7,068 32	797 55	17,837 24			30,674 91
1881	7,249 00	43,720 50	461 95	20,935 25			72,366 70
1882	7,249 00	8,945 50	358 46	22,507 45			39,060 41
1883	8,385 00	23,793 00	391 95	30,749 60			63,319 55
1884	8,385 00	10,526 00	1,259 90	27,909 72			48,080 62
1885		35,103 00	187 50	29,770 40			65,060 90
1886		22,617 00		30,461 04			53,078 04
1887		*44,040 00	198 20	†24,611 37			68,849 57
1888		30,752 50	144 20	32,406 60	$15,000 00		78,303 30
1889		*20,973 00	10 50	31,322 69	15,000 00		67,306 19
1890		*27,172 00	238 50	32,360 64	15,000 00	$15,000 00	89,771 14
1891		22,947 50	37 38	34,750 54	15,000 00	16,000 00	88,735 42
1892		22,947 50	137 38	34,948 12	15,000 00	17,000 00	90,033 00
1893		18,862 50	10 50	37,927 04	15,000 00	18,000 00	89,800 04
1894		18,862 50	433 59	44,527 26	15,000 00	19,000 00	97,823 35
1895		‡19,000 00	10 50	45,301 85	15,000 00	20,000 00	99,312 35
1896		‡16,000 00		43,886 40	15,000 00	21,000 00	95,886 40
1897		§17,700 00		43,779 54	15,000 00	22,000 00	98,479 54
1898		17,500 00		47,508 28	15,000 00	23,000 00	103,008 28
1899		¶8,750 00	705 00	52,526 11	15,000 00	24,000 00	100,981 11
1900		¶72,500 00	175 00	72,298 38	15,000 00	25,000 00	184,973 38
1901††		¶72,500 00		63,976 79	15,000 00	25,000 00	176,476 79
1902	100,000 00	**1,000 00		64,081 81	15,000 00	25,000 00	205,081 81
1903	100,000 00	**1,000 00		65,573 90	15,000 00	25,000 00	206,573 90
1904	100,000 00	**1,000 00	61 19	67,312 37	15,000 00	25,000 00	208,373 50
1905	100,000 00	*81,000 00		72,035 32	15,000 00	25,000 00	293,035 32
1906	157,810 00	*15,000 00		70,286 56	15,000 00	25,000 00	283,096 56
1907	173,410 00	**1,000 00		70,155 22	23,691 60	25,000 00	293,256 82
1908	173,410 00	**1,000 00		70,385 79	23,326 10	30,000 00	298,121 89
1909	173,410 00	**1,000 00		69,527 13	26,000 00	35,000 00	304,937 13
1910	173,410 00	**1,000 00		71,109 49	28,000 00	40,000 00	313,519 49
1911	173,410 00	**1,000 00		70,304 15	30,000 00	45,000 00	319,714 15
1912	228,800 00	**1,000 00		70,265 32	30,000 00	50,000 00	380,065 32
Totals.	$2,015,743 60	$828,937 74	$101,723 66	$1,701,435 97	$446,017 70	$595,000 00	$5,688,858 67

*Including appropriation for weather service.
†October 1, 1886, to June 30, 1887, nine months.
‡Including $5,000 for institutes and $1,000 for weather service.
¶Including $5,500 for institutes and $1,000 for weather service.
|| Including $5,500 for institutes and $1,000 for weather service.
§Including $2,750 for institutes and $500 for weather service.
††To June 30. **Weather service.

SUMMARY OF INVENTORY, JUNE 30, 1912.

College farm and park, 671 acres		$67,100 00
Athletic field and drive, 13 acres		1,300 00
Buildings—		
Library and museum, built 1881	$22,000 00	
College hall, built 1856	12,000 00	
Wells hall, rebuilt 1905-06	55,000 00	
Williams hall, built in 1869	30,000 00	
Abbot hall, built 1888, addition in 1896	15,000 00	
Chemical laboratory, built 1871, south end addition 1881, east end addition 1911	35,000 00	
Machine shops and foundry, 1885, south end addition 1887	15,000 00	
Veterinary laboratory, built 1885	5,000 00	
Horticultural laboratory, built 1888	7,000 00	
Entomological laboratory, built 1889, imp. 1897	7,500 00	
Botanical laboratory, built 1892, imp. 1909	20,000 00	
Armory, built 1885	6,000 00	
Greenhouse and stable, built 1873, 1879, rebuilt 1892 and 1902	6,000 00	
Boiler house and chimney, built 1893-4	3,000 00	
President's and two frame dwellings, built 1874	12,000 00	
Six brick dwellings, built 1857, 1879 and 1884	18,000 00	
One frame house, built 1885	3,500 00	
Howard Terrace dwelling, built 1888	13,000 00	
Farm house dwelling, built 1869	2,000 00	
Herdsman's dwelling, built 1867	400 00	
Six barns at professors' houses	1,050 00	
Horticultural barn and shed, built 1868, 1875 and 1877	1,200 00	
Bull barn, rebuilt 1905	1,500 00	
Sheep barn, rebuilt 1906	2,500 00	
Horse barn, built 1906	5,000 00	
Grade herd barn, rebuilt 1905	4,000 00	
Piggery, rebuilt 1907	1,500 00	
Dairy barn, rebuilt 1900	4,000 00	
Farm mechanics building, built 1881	1,500 00	
Poultry house, built 1906	1,000 00	
Incubator house, built 1906	500 00	
Poultry house, built 1907	1,500 00	
Three poultry houses, built 1907	300 00	
Ten brooder houses, built 1908	250 00	
Corn barn, built 1878	400 00	
Stock judging barn, built 1894	200 00	
Brick work shop, built 1857	500 00	
Observatory, built 1880	100 00	
Bath house and fittings, built 1902-3	17,000 00	
Paint shop, rebuilt 1903	300 00	
Hospital, built 1894	3,000 00	
Waiting room and book store, built 1902	1,700 00	
Lumber shed, mechanical department	250 00	
Three silos	600 00	
Coal shed, built 1899	700 00	
Women's building, built 1900	91,000 00	
Dairy building, built 1900	15,000 00	
Bacteriological building, built 1902	27,000 00	
Power house, built 1904	25,000 00	
Amount carried forward	$495,950 00	$68,400 00

Amount brought forward	$495,950 00	$68,400 00
Buildings—Continued.		
Coal shed, built 1905	6,500 00	
Tunnel system, built 1904	45,000 00	
Cold storage, rebuilt 1905	2,000 00	
Engineering building, built 1906-07, including heating	110,000 00	
Iron bridge over Cedar river, built 1888	1,500 00	
Bridge to athletic field	500 00	
Manure shed	600 00	
Four hospital cottages, built 1909	6,000 00	
Agricultural building, built 1909	182,000 00	
Lumber shed, built 1911	650 00	
Tile silo	500 00	
Piggery for serum production	1,000 00	
		852,200 00
Division of Agriculture—		
Department of Agricultural Education		624 04
Department of Animal Husbandry—		
Office library	$1,009 87	
Office	193 64	
Live stock	8,735 50	
Feed	438 30	
Miscellaneous	351 25	
		10,728 56
Department of Farm Crops		2,070 35
Department of Dairy Husbandry—		
Live stock	$8,115 00	
Dairy barn	622 10	
Office	711 58	
Live stock library	611 00	
Dairy building equipment	1,419 92	
Miscellaneous	768 55	
		12,281 15
Dean's office		2,275 53
Department of Farm and Horses		
Horses	$8,850 00	
Office	303 07	
Small horse barn	103 14	
Corn crib	277 15	
Large horse barn	1,657 38	
Tool barn	1,865 66	
		13,056 40
Department of Farm Mechanics		
Office	$353 30	
Cement laboratory	319 04	
Wood shop	1,231 05	
Forge shop	1,590 77	
Machine laboratory	1,738 33	
		5,232 49
Department of Forestry		
Office	$406 08	
Wood technology	1,764 00	
Dendrology equipment	1,025 88	
Photographic supplies	1,061 46	
Camp equipment	1,751 31	
Nursery utensils	253 81	
Nursery stock	3,664 15	
Silviculture	15 35	
Specimens	20 20	
Books	406 35	
Exhibits	756 03	
		11,124 62
Amount carried forward		$977,993 14

Amount brought forward		$977,993 14
Department of Horticulture—		
Office	$1,593 13	
Tools	797 78	
Classroom	393 50	
Laboratory equipment	482 75	
Teams and harness	1,033 50	
Greenhouse plants	1,064 25	
		5,364 91
Department of Poultry		2,182 47
Department of Soils—		
Apparatus and supplies	$3,142 43	
Furniture	503 24	
Photographic supplies	149 71	
College extension	16 40	
Chemicals	38 45	
		3,850 23
Division of Engineering—		
Department of Civil Engineering—		
Astronomical equipment	$1,598 55	
Blue printing, drawing and photography	263 86	
Cement laboratory	1,994 56	
Drafting and computing devices	4,383 31	
Hydraulic laboratory	2,057 73	
Library	320 84	
Surveying instruments	10,910 98	
Tools	85 67	
		21,615 50
Department of Drawing and Design		5,654 52
Department of Mechanical Engineering—		
Office and classroom equipment and supplies	$12,040 78	
Experimental laboratory	14,861 27	
Machine shop	14,605 17	
Forge shop	2,310 52	
Foundry	1,701 92	
Wood shop	4,619 92	
		50,139 58
Department of Physical and Electrical Engineering—		
Furniture	$2,983 63	
Shop and stock	601 94	
Mechanics	1,632 40	
Sound	174 30	
Light	1,775 55	
Heat	625 05	
Electricity and magnetism	3,488 80	
Condensers	231 75	
Galvanometers	557 00	
Resistance boxes	1,018 92	
Standard resistances	89 50	
Bridges	486 00	
Motors and generators	6,314 00	
Wattmeters	658 00	
Voltmeters	716 00	
Ammeters	705 75	
Starting boxes	113 00	
Transformers	1,483 00	
Rheostats	170 50	
Miscellaneous	1,227 42	
		25,052 51
Amount carried forward		$1,091,852 86

Amount brought forward		$1,091,852 86
Division of Home Economics—		
Reception room and hall	$731 19	
Dean's office	239 64	
Gymnasium office	144 81	
Gymnasium	554 43	
Day Student's waiting room	215 20	
Recitation room	45 85	
Parlor	651 00	
Guest room	65 85	
Second floor	192 20	
House library	88 55	
Music room	2,703 00	
Domestic science	1,244 72	
Domestic art	1,040 03	
Howard Terrace	500 02	
Dormitory furniture	1,536 21	
Miscellaneous	209 01	
Laundry	125 81	
		10,287 52
Miscellaneous—		
Carpenter shop		3,018 79
Cleaning		673 46
Farmers' Institutes		503 35
Hospital, general		261 93
Hospital cottages		875 90
Nursery and orchard inspection		62 85
Paint shop		1,113 96
President's office		912 40
Registrar's office		342 65
Secretary's Office—		
Furniture and equipment	$917 99	
Supplies	1,712 74	
		2,630 73
Weather service		1,169 77
Division of Science and Letters—		
Department of Bacteriology—		
Literature	$562 41	
Chemicals	1,081 87	
Apparatus	8,771 03	
Furniture and office supplies	967 58	
		11,382 89
Department of Botany—		
Apparatus and supplies	$726 99	
Miscellaneous	571 90	
Books and charts	1,184 35	
Botanical museum	50 00	
Chemicals	106 08	
Furniture	1,848 50	
Glassware and porcelain	515 78	
Herbarium	6,790 30	
Microscopes	3,280 15	
Tools	60 90	
		15,134 95
Department of Chemistry—		
Furniture and fixtures	$6,627 07	
Graduated glassware	1,871 07	
Ungraduated glassware	6,213 14	
Organic chemicals	419 00	
Inorganic chemicals	1,257 42	
Electrical supplies	1,249 88	
Apparatus and supplies	14,579 76	
Specimens	354 00	
Tools	523 10	
Amount carried forward	$33,094 44	$1,140,224 01

Amount brought forward	$33,094 44	$1,140,224 01
Department of Chemistry—Continued—		
Assay room supplies	266 50	
Miscellaneous	319 60	
		33,680 54
Department of English		900 52
Department of Entomology—		
Furniture and collections	$3,706 52	
Books and charts	246 81	
Apparatus	1,221 86	
Supplies	463 59	
		5,638 78
Department of History and Economics		557 75
Library		63,261 48
Department of Mathematics—		
Office furniture	$248 80	
Books	56 58	
		305 38
Department of Meteorology		87 86
Department of Military Science and Tactics—		
Furniture and fixtures	$1,256 29	
Band properties	1,366 00	
		2,622 29
Department of Physical Culture and Athletics—		
Armory and gymnasium	$453 00	
Bath house	40 40	
Office	263 25	
Athletic field	133 10	
		889 75
Department of Physiology and Zoology—		
General museum	$18,888 00	
Academic department	2,842 60	
Dissecting department	50 45	
Drawing instruments and material	10 95	
Geological apparatus	261 99	
Microscopes	2,979 37	
Photographic supplies	216 85	
Tools	132 23	
Miscellaneous	533 43	
		25,915 87
Division of Veterinary Science—		
General equipment	$670 04	
Pharmacology	689 94	
Surgery	1,266 18	
Anatomy	3,685 28	
		6,311 44
Division of Water, Heat and Light—		
Telephone department	$2,838 89	
Office furniture	119 50	
Water works plant	10,150 00	
Fire department	2,729 00	
C. B. E. stock	3,517 81	
C. B. E. tools	1,960 77	
Steam heating plant	16,588 00	
Heating stock	2,927 90	
Electric light stock	2,834 06	
		43,665 93
Total		$1,324,061 60

SUMMARY OF EXPERIMENT STATION INVENTORY.

Lands donated to the station—		
80 acres at Grayling, fenced and improved at cost	$1,000 00	
5 acres at South Haven, fenced and improved	1,000 00	
160 acres at Chatham, including buildings	6,000 00	
620 acres at Chatham, unimproved	6,200 00	
		$14,200 00
Buildings—		
Bacteriological stable	$3,700 00	
House	1,000 00	
Station Terrace building	3,000 00	
Seed room	500 00	
Slaughter house	625 00	
Storage barn	600 00	
Insectry	1,000 00	
Soil house	1,000 00	
		11,425 00
Experiment Station—		
Division of Bacteriology—		
Literature	$2,179 64	
Apparatus	9,510 57	
Fixtures and office supplies	258 59	
Chemicals	729 32	
		12,678 12
Division of Botany—		
Scientific apparatus	$2,478 89	
Microscopes and photo apparatus	880 56	
Laboratory supplies	206 63	
Glassware	290 70	
Books	104 97	
Office furniture and supplies	497 23	
Chemicals	249 35	
		4,708 33
Bulletin room		453 82
Division of Chemistry—		
Chemicals	$468 46	
Glassware	1,173 53	
Porcelain ware	181 94	
Office furniture and supplies	541 73	
Miscellaneous	3,882 67	
		6,248 33
Director's office		469 18
Division of Entomology—		
Furniture and supplies	$580 37	
Miscellaneous	2,206 57	
Books	958 48	
Apparatus	1,473 79	
Chemicals and chemical supplies	254 74	
Stains	18 68	
Spraying machinery	56 20	
Tools	21 02	
Glassware	439 36	
		6,009 21
Farm Division—		
Division of Horticulture		2,068 27
Sundry	$1,126 75	
Tools	161 80	
		1,288 55
Experiment Station Library		7,081 50
Division of Soils		1,049 88
South Haven Experiment Station		309 56
Upper Peninsula Experiment Station		2,068 37
Total		$70,058 12

REPORT OF THE PRESIDENT.

To the Honorable State Board of Agriculture:

Another very successful year of college work has passed into history. Teachers and students seemed to enjoy their work and on the whole very satisfactory results were attained. As usual the attendance was larger than any previous year, yet not so large as to be unwieldy or to render impossible systematic and thorough instruction.

Commencement exercises were held in the armory on June 18th. On the preceding Sunday the Rev. John Knox McClurkin, D. D., of Pittsburgh, gave the baccalaureate sermon. Dr. A. Ross Hill, president of Missouri University, delivered the commencement address. He spoke to a large audience on Vocational Education. The class numbered 165. Of this number 54 graduated from the Engineering course, 66 from the Agricultural course, 15 from the Forestry course and 30 from the Home Economics course. Their names and addresses are as follows:

NAMES OF GRADUATING CLASS.

(Students in Agriculture are designated by *a*; Engineering by *e*; Home Economics by *h*; Forestry by *f*.)

Name.	Post Office.	County.
Allen, Fernelle Marie, *h*	East Lansing	Ingham.
Allen, Verna Sprang, *h*	East Lansing	Ingham.
Anderson, Vivian Gordon, *e*	Bay City	Bay.
Anker, Samuel Lincoln, *e*	East Tawas	Iosco.
Armstrong, Edward Clayton *e*	Farwell	Clare.
Ashley, Lee Jones, *a*	Davison	Genesee.
Bacon, Grace Priscilla, *h*	Chelsea	Washtenaw.
Baden, Philip T., *a*	Kalamazoo	Kalamazoo.
Badour, Arlie, *a*	St. Joseph	Berrien.
Baker, Charles Bradley, *f*	Bancroft	Shiawassee.
Ballard, Clinton Vede, *a*	Ithaca	Gratiot.
Bancroft, Harry Lee, *a*	Lansing	Ingham.
Barnum, Carl Fisk, *a*	Coats Grove	Barry.
Barnum, Harold Herbert, *a*	Coats Grove	Barry.
Barrows, Frank Lawrence, *e*	Three Rivers	St. Joseph.
Bender, Edward Roscoe, *e*	Litchfield	Hillsdale.
Benner, Lee Oscar, *e*	Dowagiac	Cass.
Bennett, Donald Morrison, *e*	Traverse City	Grand Traverse.
Berridge, Ashley Moses, *a*	Greenville	Montcalm.
Binding, Lee Ross, *a*	Dansville	Ingham.
Blair, Duane Alger, *e*	Detroit	Wayne.
Bone, Harry Earle, *e*	Reed City	Osceola.
Bovay, Arthur Grant, *f*	Rodney	Mecosta.
Branch, George Verne, *a*	Petoskey	Emmet.
Brault, George, *f*	Lake Linden	Houghton.
Brown, Ella Lentz, *h*	East Lansing	Ingham.
Browning, Irving Robert, *f*	Iron Mountain	Dickinson.
Brumm, Lynn Stuart, *a*	Nashville	Barry.
Buckham, Valentine, *a*	Kalamazoo	Kalamazoo.
Burns, Charles Glenn, *f*	Leonard	Oakland.
Caldwell, Theodore Halleck, *a*	Bay City	Bay.
Carl, Rollin Dennis, *e*	Lansing	Ingham
Carmody, John Henry, *a*	Grand Rapids	Kent.
Carter, Anna Irene, *h*	Benton Harbor	Berrien.
Chilson, Clinton Hammond, *a*	Lansing	Ingham.
Coffeen, Curtis Linden, *a*	Mayville	Tuscola.
Coffeen, Vera Bates, *h*	Mayville	Tuscola.
Coplan, Heiman Hugh, *e*	Traverse City	Grand Traverse.
Cronk, Arthur Walter, *a*	Detroit	Wayne.
Crysler, Frederick William, *a*	Dansville	Ingham.
Culver, Edward Gifford, *e*	Midland	Midland.

NAMES OF GRADUATING CLASS.—*Continued.*

Name.	Post Office.	County.
Davis, Harry Stephen, *f*	Dutton	Kent.
Day, Arthur Elkaney, *a*	Bellevue	Eaton.
Dearborn, Elida Antoinette, *h*	Bellaire	Antrim.
DeGraff, Earl Waldo, *a*	Buffalo	N. Y.
Delvin, Ray Birn, *e*	Lansing	Ingham.
Delvin, Sylvester Flint, e	Lansing	Ingham.
Dickinson, Charles Harry, *e*	Grand Haven	Ottawa.
Dickson, Matthew Ellis, *a*	East Lansing	Ingham.
Driesback, Robert Chester, *a*	Parkville	St. Joseph.
Duddles, Ralph Emerson, *a*	Ashton	Osceola.
Edwards, Donna Smith, *h*	Owosso	Shiawassee.
Eidson, Arthur Wilbur, *a*	Berrien Springs	Berrien.
Ellis, Grace, *h*	Flushing	Genesee.
Eyer, Lloyd Elmer, *a*	Alma	Gratiot.
Fisher, Durward Frederick, *a*	Clarence	N. Y.
Gabel, Gordon George, *f*	St. Joseph	Berrien.
Gallup, Edward Everett, *a*	Adrian	Lenawee.
Gardner, Leon Burns, *a*	Lansing	Ingham.
Gardner, Max William, *f*	Lansing	Ingham.
Gardner, William Alfred, *a*	Bucyrus	OHIO.
Garvey, Clarence Ross, *f*	Milwaukee	WISCONSIN.
Geagley, William Carl, *f*	Bristol	VIRGINIA.
Gearing, Milton John, *e*	Detroit	Wayne.
Geib, Horace Valentine, *a*	Caledonia	Kent.
Gifford, Charles Ralph, *e*	Davison	Genesee.
Gilbert, Gale White, *a*	Adrian	Lenawee.
Gilbert, Inez Martha, *h*	Moline	Allegan.
Goodell, Ralph Augustus, *e*	Lansing	Ingham.
Groothius, Herman, *e*	Detroit	Wayne.
Hall, Sumner Lovern, *e*	Stockbridge	Ingham.
Hammond, Hunter L., *e*	East Lansing	Ingham.
Hard, Leon Delos, *a*	East Lansing	Ingham.
Hansen, Nels, *e*	Muskegon	Muskegon.
Harris, John Jesse, *e*	Lansing	Ingham.
Harrison, Charles Lee, *a*	Constantine	St. Joseph.
Hart, Josephine Rena, *h*	Otsego	Allegan.
Hawkins, Lucile Maude, *h*	Reed City	Osceola.
Hebard, Frank Foster, *a*	Grand Rapids	Kent.
Helm, Leslie Cornell, *e*	Saugatuck	Allegan.
Hendrick, Herbert Bradley, *a*	East Lansing	Ingham.
Himmelberger, Leo Ransom, *a*	Lansing	Ingham.
Holden, John Arthur, *e*	South Frankfort	Benzie.
Holley, Otto Burnham, *e*	Lansing	Ingham.
Holmes, Ezra Israel, *a*	Bronson	Branch.
Horst, Emory Louis, *e*	Detroit	Wayne.
Hotchin, Earl Edward, *e*	Constantine	St. Joseph.
Hough, Howard William, *a*	Romeo	Macomb.
Howe, Bessie Gertrude, *h*	Lansing	Ingham.
Hyde, Vera Clare, *h*	Hart	Oceana.
Iddles, Alfred, *e*	South Haven	Van Buren.
Johnson, William Riker, *a*	Metamora	Lapeer.
Jonas, Joseph F., *e*	Detroit	Wayne.
Jones, Leroy Lucien, *a*	Grass Lake	Jackson.
Juergens, Edward Frank, *f*	Bay City	Bay.
Kane, Forrest Hart, *e*	Charlevoix	Charlevoix.
Kawada, Yoshio, *a*	Kure	JAPAN.
Ketchum, Verne Lee, *e*	Le Roy	Osceola.
Kimball, James Henry, *a*	Richmond	VIRGINIA.
Kirby, Ralph Gillette, *a*	Lansing	Ingham.
Knapp, Charles Wilbur, *e*	Plainwell	Allegan.
Knapp, Leo Jay, *e*	Weston	Lenawee.
Knowlton, Harry E., *a*	Fennville	Allegan.
Lautner, Ernest Stephen, *a*	Traverse City	Grand Traverse.
Lockwood, Carrie Josephine, *h*	Grand Rapids	Kent.
Logan, Margaret, *h*	Ionia	Ionia.
McDermid, Frank Harwood, *a*	Battle Creek	Calhoun.
Martin, Stanley Arthur, *a*	Fredonia	N. Y.
Mason, Preston Walter, *a*	Saline	Washtenaw.
Mead, Alfred Burton, *e*	Cass City	Tuscola.

NAMES OF GRADUATING CLASS.—*Concluded.*

Name.	Post Office.	County.
Mead, Aylwin Frances, *h*	Detroit	Wayne.
Mead, Ruth, *h*	Detroit	Wayne.
Miller, John Allen, *e*	Gladstone	Delta.
Mosley, Francis Orpha, *h*	Detroit	Wayne.
Muellenbach, Lillian Matilda, *h*	East Lansing	Ingham.
Munn, Mancel Thornton, *a*	Vicksburg	Kalamazoo.
Norton, Helen Louise, *h*	Howell	Livingston.
Nye, Reuben Lovell, *a*	East Lansing	Ingham.
Oberdorffer, Cora Alice, *h*	Stephenson	Menominee.
O'Dell, George Maywood, *e*	Bad Axe	Huron.
Palmer, George Harlie, *e*	Blissfield	Lenawee.
Parsons, Channing Wilson, *e*	Alma	Gratiot.
Pattison, Benjamin Purdy, *a*	Caro	Tuscola.
Pederson, Walter Siegfried, *e*	Cadillac	Wexford.
Potts, Aurelia Belle, *h*	Washington	Macomb.
Queal, Lawrence Reuben, *f*	Hamburg	Livingston.
Reid, Edwy Borradaile, *a*	Springfield	Mass.
Richardson, Mary Agnes, *h*	Hart	Oceana.
Robinson, Lutie Ethel, *h*	Ellsworth	Antrim.
Rowley, Harry William, *e*	Clyde	Oakland.
Ryther, Cyril Gordon, *a*	West Seneca	N. Y.
Sanford, Earl Clifford, *f*	Grass Lake	Jackson.
Schleussner, Otto William, *a*	New York	N. Y.
Schneider, Henry William, *e*	Grand Rapids	Kent.
Sheffield, George Charles, *a*	Adrian	Lenawee.
Sheldon, Helen Mildred, *h*	Eaton Rapids	Eaton.
Shuart, Albert Brinkerhoff, *e*	Lansing	Ingham.
Sindlinger, Florence Kathryn, *h*	Lansing	Ingham.
Smith, Edwin, *a*	Lodi	N. Y.
Smith, James Axtell, *e*	Big Flats	N. Y.
Smith, Philena Esther, *h*	Lansing	Ingham.
Smith, Sidney Samuel, *a*	Clarkston	Oakland.
Sorenson, Arthur Alexander, *a*	Elkton	Huron.
Spencer, Damon Alvin, *a*	Nashville	Barry.
Stahl, Charles A., *f*	Dowagiac	Cass.
Steffens, Louis Henry, *f*	Baltimore	MARYLAND.
Stone, Fred Almon, *e*	Clare	Clare.
Taft, Harry Goodell, *a*	East Lansing	Ingham.
Taylor, Hiram Erne, *a*	Scottville	Mason.
Tenkonohy, Rudolph John, *e*	Detroit	Wayne.
Tibbs, Jollie Hilliard, *a*	Ludington	Mason.
Truax, Hartley Eugene, *a*	Fennville	Allegan.
Tubbs, Clarence Caldwell, *a*	Gladwin	Gladwin.
VanDervoort, Sarah Ellen, *h*	Lansing	Ingham.
VanMeter, Morton, *e*	Cadillac	Wexford.
Van Wagenen, Kenneth Duryea, *a*	Denver	COLORADO.
Van Winkle, Roy Jesse, *e*	Tecumseh	Lenawee.
Wadd, Roy James, *e*	Middleville	Barry.
Warner, Russell Ammon, *e*	Plymouth	Wayne.
Webb, Chauncey Earl, *e*	Mason	Ingham.
Westerveld, Ira, *e*	Alba	Antrim.
White, George Alfred, *e*	Jackson	Jackson.
Wilcox, Harry Earl, *e*	St. Johns	Clinton.
Wood, Ruth Ella, *h*	E. Lansing	Ingham.
Wood, Walter Amos, *a*	Adams	N. Y.

COUNTIES REPRESENTED IN ENTERING CLASS.

Allegan	6	Kent	31
Alpena	1	Lake	1
Antrim	1	Lapeer	10
Barry	5	Leelanau	3
Bay	5	Lenawee	7
Benzie	2	Livingston	5
Berrien	13	Mackinac	1
Branch	3	Macomb	6
Calhoun	7	Manistee	3
Cass	4	Marquette	3
Charlevoix	2	Mason	4
Cheboygan	2	Mecosta	7
Chippewa	2	Missaukee	3
Clare	2	Monroe	3
Clinton	1	Montcalm	6
Delta	4	Muskegon	4
Dickinson	3	Newaygo	3
Eaton	3	Oakland	18
Emmet	4	Oceana	5
Genesee	10	Osceola	2
Gladwin	1	Ottawa	5
Gogebic	2	Presque Isle	1
Grand Traverse	5	Saginaw	10
Gratiot	9	Sanilac	3
Hillsdale	6	Schoolcraft	1
Houghton	6	Shiawassee	12
Huron	10	St. Clair	3
Ingham	72	St. Joseph	4
Ionia	7	Tuscola	5
Iosco	1	Van Buren	8
Isabella	5	Washtenaw	3
Jackson	12	Wayne	38
Kalamazoo	6		

OTHER STATES AND COUNTRIES REPRESENTED.

China	4	New York	22
Connecticut	1	Ohio	17
Illinois	7	Ontario	1
Indiana	3	Pennsylvania	5
Maryland	3	Russia	3
Massachusetts	1	South America	2
Missouri	1	Wisconsin	1
Montana	1	West Virginia	1
New Mexico	1		

STATISTICS OF ENTERING CLASS.

	Men.	Women.	Total.
Number entering	404	110	514
Average age	20.5	20.4	20.4
Schools:			
High	323	90	413
College	33	10	43
State Normal	5	5	10
State University	15	2	17
Technical	5	1	6
Military Academy	5	....	5
Preparatory	18	2	20
Support while here:			
Parents	202	86	288
Self	144	11	155
Parents and self	46	5	51
Other	12	8	20

CHURCH MEMBERSHIP.

	Members.	Preference.	Total.
Baptist	18	22	40
Catholic	40	2	42
Christian	4	1	5
Church of Christ Science	2	5	7
Church of England	2	....	2
Congregational	25	38	63
Episcopal	21	11	32
Evangelical	4	1	5
Hebrew	2	8	10
Lutheran	10	2	12
Mennonite	1	....	1
Methodist Episcopal	53	72	125
Methodist Protestant	....	2	2
No preference	....	68	68
Presbyterian	47	32	79
Presbyterian (United)	1	1	2
Reformed	3	5	8
United Brethren	1	....	1
Unitarian	....	6	6
Universalist	1	2	3

SUMMARY OF STUDENTS.

	Agricultural.	Engineering.	Home Economics.	Forestry.	Veterinary.	Totals.
Graduate students	5	1	3	......	......	9
Class of 1912	67	58	31	16	......	172
Class of 1913	71	84	40	21	5	221
Class of 1914	88	127	63	19	2	299
Class of 1915	210	131	88	......	......	429
Sub-Freshmen	50	50	29	......	......	129
Special students	50	2	10	......	1	63
Special short course students	393	......	......	......	......	393
Totals	934	453	264	56	8	1,715
Deduct names repeated	.....	......	......	......	.....	13
Net total	....	......	......	.....	......	1,702

The college loses two very able men by resignation this year in the persons of Dr. Charles E. Marshall and Dr. Thomas C. Blaisdell.

Dr. Marshall during the sixteen years of his service developed the Bacteriological department to its present efficient and commanding position. Beginning with practically nothing the department now enjoys a well equipped building and a force of eight well trained workers This department under the guidance of Dr. Marshall has not only rendered valuable service to scientific research but it has also assisted the farmer in solving his everyday problems. It is, therefore with great regret that the college parts with his services.

Dr. Thomas C. Blaisdell who has been at the head of the department of English and Modern Languages during the past six years has resigned to accept the presidency of Alma College at Alma, Michigan.

Dr. Blaisdell rendered the college very valuable service and while we are glad to be able to furnish a leader for a neighboring and worthy institution, it is with great reluctance that we relinquish our claim upon him.

Professor W. W. Johnston of the Agricultural College of Oklahoma has accepted the place made vacant by the resignation of Dr. Blaisdell. Professor Johnston has a fine record both as a student and teacher and it is believed that he will be able to maintain the fine record made by his predecessor in this department.

Dr. Blaisdell is the third person to be called from the head of this department to the presidency of another college.

It would seem scarcely necessary to repeat again the statement made in previous reports concerning the necessity for more buildings. Each year as the number of students increase the situation becomes more acute. The college is very much in need of at least half a dozen additional buildings. One-half million dollars could very properly be expended at once on new buildings without any show of extravagance or possibility of exceeding our pressing needs. But the necessity for more buildings is not the only serious difficulty confronting the Board. The widespread and persistent demand on the part of the farmers for assistance from the college makes it very desirable to employ more field men and to widen and extend the scope of the extension work. In short if the college is to meet the legitimate demands made upon it by the people of the state it must have at once a large increase in its financial support.

The only building constructed during the past year was the addition to the Chemical Building. The added laboratory and class room space thus made available has relieved, to a large extent, the congested condition of this department. This addition is a substantial two-story, fireproof structure of pressed brick, and is modern in every particular. It contains a model lecture room with a seating capacity for 250 students, and laboratory space for 286 different students at the same period. Under the report of the Department of Chemistry is given a complete description of this addition, together with floor plans and interior and exterior views of the building.

For information concerning the work of the various departments of the college, please consult the reports in the following pages.

JONATHAN L. SNYDER,
President.

East Lansing, Mich., June 30, 1912.

REPORT OF THE DEAN OF AGRICULTURE.

To President J. L. Snyder:

The past year has been a pleasant and prosperous one for the Agricultural division. There has been a marked increase in the number of students in both regular and short courses. A detailed statement of the enrollment is given later. There was manifest evidence of better preparation on the part of the entering classes. The percentage of young men from the farms who entered the courses of the division also increased. The percentage of young men attending the short courses who had partially or wholly completed high school courses continued to increase. The short courses were completed without serious interruption. The summation of the classification of the regular and short course students shows a total enrollment of 993 in the division during the year. This does not include those who attended the one week courses in poultry and dairying.

The following is a statement of the number of students enrolled in the Agricultural division during the year:

Special Short Course Students, Winter Term, 1912.

General Agriculture, first year, eight weeks	183
General Agriculture, second year, eight weeks	51
Creamery, first year, six weeks	47
Creamery, second year, six weeks	2
Cheese, four weeks	3
Poultry, eight weeks	18
Fruit, seven weeks	43
Beet Sugar, four weeks	46
	393

Students enrolled during 1911-12 in Agriculture and Forestry.

Post Graduates	5
Seniors	79
Juniors	94
Sophomores	109
Freshmen	209
Sub-freshmen	59
Specials	45
	600

The policy of the division has been to establish and develop an organization of symmetry and uniformity. The various department heads and those in charge have pursued this policy consistently throughout the year until the division as a whole is now in good condition to ad-

minister the courses offered with a fair degree of satisfaction. The uniformity in the strength of development is well illustrated in the strength of the various animal classes including poultry, swine, sheep, beef and dairy cattle and heavy draft horses. With a rapidly increasing student body, however, more and more attention must be given the matter of efficiency in instruction for there is danger of other influences diverting and holding the attention, of attempts to handle too many students in each section and also of requiring the instructor to attempt more than can be accomplished well.

The extension work of the division has met with marked success. Details of this work are to be found in connection with the reports of the various departments directing the work.

A new line of endeavor was opened up in the form of the forestry extension work during the year. In April the State Board of Agriculture selected and appointed Mr. C. A. Tyler of Coldwater to take up this work. Mr. Tyler has an extensive knowledge of the Michigan farm wood-lot situation and is undertaking to stimulate and develop a state wide interest toward the preservation and improvement of farm timber lands. Thus far he has been getting in touch with the situation largely through the agency of those interested in, and in attendance at, the high schools where Agricultural courses have been introduced. Mr. Tyler is now about to begin the organization of local forestry associations, with the object of stimulating interest and establishing ties tending to a continuance of effort in tree preservation and planting.

Since Mr. L. M. Geismar was appointed in March to represent the college in the Upper Peninsula in extension work his efforts have met with marked success. The following is a statement of the organizations formed up to date, viz:

Fourteen Alfalfa Clubs including 185 members located at Allenville, Brimley, Cooks, Daggett, Fayette, Harwood, Ironwood, Lake Linden, Metropolitan, National Mine, Perkins, Vulcan, Waucedah and Kaleva.

Ten Potato Clubs including 132 members distributed as follows: Bark River, Baraga, Covington, Daggett, Garden, Ironwood, Ontonagon, Powers, Stephenson and Wetmore.

Thirteen Corn Clubs including 188 members at the following places: Allenville, Brimley, Cooks, Covington, Eroen, Ironwood, L'Anse, Manistique, National Mine, Newberry, Stephenson and Wetmore.

And one Fruit Growers Club at Marquette with a membership of 14.

In addition to these lines of effort Mr. Geismar has made many demonstrations such as proper methods of pruning, spraying, etc., in fact has been prepared to give advice and assistance on all kinds of farm problems whenever possible.

The following is a statement of the work of Mr. W. F. Raven, Live Stock Field Agent, who was also employed part of the time in other phases of agricultural extension work.

"Beginning with July 1, 1911, I assisted with the 'Summer Course in Practical Agriculture.' The first two weeks in August were spent on the 'Wheat train.'

At this time the field work in live stock was resumed and during the year the following work was accomplished: Visits were made to 546 farms on which 3,850 cows were owned. While some of the farms were visited in the interests of farm management, in all cases better live stock

was urged. Six Breeders' Associations have been organized, viz: Fairview, (Guernsey); Menominee, (Holstein); Birch Creek, (Jerseys); Harrisville, (Brown Swiss); Ontonagon, (Holstein); Dundee, (Holstein).

I have aided several farmers in getting started with herds of pure bred cattle and in getting pure bred sires of which I have no record.

One-day Farmers' Institutes were attended by me in Alpena, Crawford, Menominee, Delta, Dickinson, Iron and Schoolcraft counties. Two-day institutes were also attended in Ionia, Monroe, and several other counties.

I assisted in the one week high school lecture courses at Union City, Watervliet and Hillsdale giving two lectures per day on live stock topics. Also attended the Menominee County Agricultural School Short Course and gave lectures on live stock and dairying.

I attended the Western Michigan Fair at Grand Rapids as Superintendent of Cattle and also assisted Prof. Anderson at the State Fair in dairy demonstration work.

Considerable study has been made and notes and photographs taken to show the condition of the cut-over lands of Michigan and to get data on the cost of clearing the same. The last few weeks of the year have been spent in superintending the clearing of land in the Upper Peninsula. This work is being done with Finnish laborers and considerable experience and data are being secured on methods and cost of clearing in that particular region."

The real value of the various forms of extension work cannot be estimated by the number of organizations formed or the total membership. Nor is the character of the organization the determining factor. It is now quite apparent that, where interest is stimulated even in one direction only, this eventually spreads to all lines of farm activity and even results in improved conditions of rural life. For example, we shall give a brief statement of the results of the organization in one locality. The members were pledged for one specific purpose only, viz: improved cattle breeding. Soon, however, they were figuring on rations and purchasing cotton seed meal; records of the production of individual cows were being kept; silos were being erected; commercial fertilizers were being used; improved varieties of grain grown and the general horizon widened by extending the scope of reading in the home. The power of the example of members of these organizations in the community is bound to exert a powerful influence for the improvement of Michigan agriculture.

Respectfully submitted,

R. S. SHAW,

Dean of Agriculture.

East Lansing, June 30, 1912.

REPORT OF THE DEPARTMENT OF HORTICULTURE AND LANDSCAPE GARDENING.

To the President:

Sir—The class work has been given during the past year, according to the schedule and in the same way that it has been carried on during the past few years.

There has been a steady increase in the number of students specializing in the Horticultural department. In the class of 1909, there were 5 graduates and in the class of 1912 there were 24; in the class of 1913 there will be about 35. This large increase in the number of students emphasizes the inadequacy of our facilities and equipment. The greenhouse equipment is far from being sufficient as has been referred to in previous reports. The laboratory, erected in 1888, is now out of date and not at all satisfactory for teaching modern horticulture, in addition to being far too small. It has become necessary to depend upon other departments for class-rooms and laboratories.

Since horticulture is one of the most important industries in Michigan, it is reasonable to expect that the Horticultural department of this college should have housing and equipment in keeping with the importance of the industry. Nearly every college or university in neighboring states is improving its Horticultural department facilities and it is to be hoped that Michigan will not fall behind these states in this important kind of progress.

The extension work in horticulture has continued to grow and prosper. The plan of conducting the work has been practically the same as last year. Early in the spring, a complete series of lectures and orchard demonstrations on tree pruning, winter spraying, summer spraying, thinning, grading and packing were arranged in 25 different communities of the state and with but few exceptions, these have or will be completed. In a large number of other communities, one or more separate demonstrations have been held. Each demonstration is planned as nearly as possible at the correct time of year for the work to be done. A thorough discussion of the subject in hand is given and then the lecture is followed by an actual demonstration of the work. An effort is made to select orchards or trees on centrally located farms and along frequently traveled highways. This makes it possible for those in attendance to not only hear discussion of the ordinary and proper cultural operations of an orchard, but they see the work properly done and can also easily watch the results upon the trees and crops throughout the season and draw conclusions for themselves. The demonstrations have been liberally attended and the effect has been that, without exception, there has followed a much increased interest in the care of orchards of the several communities and in a great many cases, the influence has been very apparent and remarkable. We have tried the idea that is being tested in some other states of having the demonstrator spend about one hour with individual farmers on his farm, but our results from this system were not as good as those which followed a

demonstration where the interested individuals all came together on one farm.

The "Fruit Show" held early in the winter term, managed entirely by the horticultural students, was much larger and more successful than the three previous attempts. Sample lots of fruits from many states are secured by exchange or are presented to the department by former students. This fruit show is enjoyed by the entire community, including Lansing.

The Short Course in Fruit Growing this year had 43 students. Several members were graduates from colleges and universities. The assistance of the Departments of Botany, Entomology, Soils, Farm Mechanics and the Chemical Division of the Experiment Station helped to make this course a success. In the past, only instruction in fruit growing has been given but there has been a demand for some instruction in vegetable growing and market gardening. It may be wise to extend the course from six to eight weeks and use the last two weeks for instruction in market gardening and to make this a somewhat separate course and try to induce market gardeners of the state to come here for that time and to secure special instructors for some of this work.

The department has sent quite complete exhibits of horticultural interest to the West Michigan State Fair at Grand Rapids; the Michigan State Fair at Detroit and the first Apple Show at Grand Rapids in November, as well as on the Farmers' Institute train in June. With all of these exhibits, a man has been in constant charge to explain the points and to answer questions.

The usual number of meetings of horticultural societies and farmers' institutes have been participated in by members of the Horticultural department.

The first change in the staff of the department in three years was made when Instructor O. I. Gregg resigned last September, to engage in commercial fruit growing. Mr. G. W. Hood, a graduate of the Ohio State University in 1909, succeeded Mr. Gregg.

I am very pleased to report a spirit of loyalty and co-operation among all the members of the department and that the services of Assistant Professor C. P. Halligan, Instructors Thomas Gunson and G. W. Hood, Field Agent O. K. White and Foreman A. H. Davis have been thoroughly satisfactory.

Respectfully submitted,
H. J. EUSTACE,
Professor of Horticulture.

East Lansing, June 30, 1912.

REPORT OF THE DEPARTMENT OF DAIRY HUSBANDRY.

To the President:

Sir—I have the honor to hand you herewith the report of the Department of Dairy Husbandry for the year ending June 30, 1912.

The year has been marked by increased work in all lines in which this department is interested. So insistent and mandatory have been the demands upon our time for instructional work that the experimental ventures have been temporarily checked and many calls for extension assistance have been denied.

During the fall term 30 seniors and specials took the course in Creamery Buttermaking. In the spring term 120 sophomores and specials were given instruction in Milk Testing and Farm Dairying, while 15 seniors selected the course in Market Milk.

The special courses for creamery men and cheese makers were well attended during the winter term, 52 men being registered in these classes, while there were 50 men from the general agricultural short course instructed in Farm Dairying.

The instructional work in Dairy Live Stock as provided for in connection with the several courses in Animal Husbandry, as well as similar instruction for the short course students, has also been given during the year.

We have had the able assistance of Harold W. Newhall as instructor in Dairy Manufactures throughout the year. Simon Hagedorn, Chas. Dear, H. D. Wendt and Max L. Johnston also rendered valuable aid during the special courses.

The duties contingent upon the supervision of Advanced Registry tests for dairy cattle are steadily increasing. From July 1, 1911, to June 30, 1912, over 800 assignments of testers were made. All reports for these tests are reviewed in this department before forwarding to the several Registry Associations; collection for the services and traveling expenses of the testers is made from the farmers and turned over to the men employed to do the work. There has been handled through this office during the past year nearly $7,000 for this purpose, and 25 men were employed at one time during the busiest part of the season.

Every year an increasingly large number of inquiries from the farmers of the state relative to dairy and live stock matters are dealt with by correspondence, many samples of milk and cream are tested, and such other duties performed as render consistent assistance to the dairy interests of the state.

With the construction of the more commodious and modern building for dairy manufactures about to be provided, the business of this department will be greatly facilitated, and its efficiency can be materially increased.

Respectfully submitted,

A. C. ANDERSON,

Professor of Dairy Husbandry.

East Lansing, June 30, 1912.

REPORT OF THE DEPARTMENT OF ANIMAL HUSBANDRY.

Pres. J. L. Snyder:

Dear Sir—During the past year instruction work has been given to a total of 495 men, a number somewhat smaller than last year due to the fact that the study of breeds has been put forward to the junior year and was not given last year.

In Animal Husbandry I, required of freshmen agricultural students during the fall term, 192 men were enrolled and handled in two sections of 96 men each. This proved far too large a class for one instructor. The addition of Mr. Spencer to the staff will help out materially. We feel, however, that in justice to the students, sections of under classmen should be limited to 40 men each, and that not more than 25 juniors or seniors should be allowed in one section.

In Animal Husbandry V, 40 seniors were enrolled. In order to give this class an opportunity to do some practical judging work, the fairs at Flint and Fowlerville were visited. These trips proved of great value to the students. More time should be allowed the class for this work.

The winter term was largely devoted to work with short course men. One hundred eighty-one men were enrolled in the first year's work. Each year sees a better prepared class of men taking this work, last year's class containing many men eligible to our four-year course, and a few who held degrees from other institutions. Fifty-three men returned for the second year's work.

Twenty-seven seniors were enrolled in Animal Husbandry VI. This work was very ably handled by Prof. Norton, who assisted in the department during the short course.

The department now has foundation herds of all the leading breeds of beef cattle, sheep and swine, which we hope to improve each year by retaining only the most promising of the offsprings.

While no funds have been available for experimental work the past year, records of the cost of maintaining the breeding herds of beef cattle and ewe flocks have been carefully kept, and some very interesting data obtained.

Respectfully submitted,
GEORGE A. BROWN,
Instructor in Charge.

East Lansing, June 30, 1912.

REPORT OF THE DEPARTMENT OF FARM CROPS.

President J. L. Snyder:

I herewith submit a report of the Department of Farm Crops for the year ending June 30, 1912.

The several courses offered by the department have been given as outlined in the college catalog. During the fall term instruction was given to 28 junior students in Farm Crops 2, and to 13 senior students in Farm Crops 3. During the winter term instruction was given to 237 freshmen students in Farm Crops 1, 42 senior students in Farm Crops 4, 183 first year short course students and 51 second year short course students. During the spring term instruction was given to 130 sophomore students in Farm Crops 2 and 28 senior students in Farm Crops 5. Instruction has also been given to 2 graduate students during the year, one of which has taken his major and one his minor in this department. The total number of students taking work in this department during the year has been 714.

During the year the department has secured additional equipment for the laboratory, in the way of laboratory cases, cans for the storing of judging samples of small grains, grass seeds, etc., trays for the storing and judging of corn germinators, dissecting sets, etc. Numerous charts and lantern slides have also been prepared to supplement the work in the classroom.

An effort is now being made to systematize and standardize the instruction work of the department. On account of the many variable factors upon which crop production depends, it has been difficult in all our agricultural colleges to place the instruction in Farm Crops on a basis similar to that in the more exact sciences. It is hoped, however, to reduce the instruction of the department to a more definite pedagogical basis which will deal mainly with fundamental principles and give the student a broad conception of the more important factors of crop production.

Respectfully submitted,
V. M. SHOESMITH,
Professor of Farm Crops.

East Lansing, June 30, 1912.

REPORT OF THE DEPARTMENT OF SOILS.

President J. L. Snyder:

Dear Sir—The year of 1911-12 has brought to the Soils department an increased volume of work. Six hundred eighty students have received instruction. Of this number 267 were short course students.

A trip of inspection was made by members of the Farm Management class to five successfully operated farms. Some 30 men made the trip. Each farm visited is characterized by some marked feature of agriculture, and from each the students gathered new definite suggestions not found in books. This feature of instruction in practical agriculture is greatly appreciated by those who take advantage of it.

As indicated a year ago, we are continually modifying our courses, having in mind always the development of courses that shall be in the highest degree practical and correct. The increasing numbers electing work in this department seem to confirm our judgment in these matters.

The developments of the past year make it imperative that our force be increased if we are to give to each student the individual attention he should receive.

Our equipment of apparatus is still incomplete largely because what we are seeking is not to be had on the markets. We are, therefore, under the necessity of designing apparatus to meet our needs, and this we are doing.

Numerous calls still come to us for extension work. We have given such time to institutes and other farmer, juvenile and educational meetings as time would permit, but have been compelled to decline a considerable number of invitations to attend such meetings.

Respectfully yours,

JOS. A. JEFFERY,

Professor of Soils and Soil Physics.

East Lansing, June 30, 1912.

REPORT OF THE DEPARTMENT OF POULTRY HUSBANDRY.

Pres. J. L. Snyder:

Sir—I have the honor to submit the following report of the Department of Poultry Husbandry for the year ending June 30, 1912.

Though under new management it has been the aim in the department to continue the very excellent courses started by those previously in charge and to add as rapidly as seems consistent with present conditions several features which make possible better co-operation between the department and the people of the state.

The course of instruction outlined by Prof. Kempster has proved successful thus far, there being good attendance and interest in class work. For the regular senior work 10 students enrolled in Poultry 2,

14 in Poultry 3, and 25 in Poultry 4. Forty-six men enrolled for Poultry 1 which is a required junior study, and there were 21 who took the special eight weeks short course.

The Second Annual Poultry Week held in February was well attended and an excellent program rendered. The speakers who assisted from outside were Prof. W. R. Graham, Professor of Poultry Husbandry, Guelph, Ontario, Canada; Prof. A. G. Philips, Purdue University, Indiana; Franklane L. Sewell, Niles, Michigan, and Mrs. W. Dawson, London, Canada. The severity of the weather made many breeders withhold birds from the poultry show which was the fourth annual event and held in conjunction with the poultry week, but the quality of stock shown were very good. Judges Tucker and Wise, both of Michigan, officiated in placing awards.

In December 8 members of the senior poultry class attended the Winter Fair and Poultry Show in Guelph, Ontario, where more than 5,000 birds were exhibited, thus giving an excellent opportunity to study the varieties of fowls as well as market conditions, and at the same time benefit by the general fair which in management corresponds to our Chicago International.

The call for lecture work and judging of county fair poultry exhibits and poultry shows was so urgent that it has been possible to give some of our senior students good practical work in meeting the demand. Fifty lectures have been given about the state to an aggregate of more than 2,000 people. The department has furnished judges for five county fair exhibits and six poultry shows.

Since the organization of the Michigan Poultry, Butter and Egg Shippers' Association in March, the department has made a special effort to co-operate with this association in improving the condition of the farm egg.

It was a great pleasure this year to be host to the American Association of Instructors and Investigators in Poultry Husbandry who held their annual meeting here in June. Representatives were present from 16 states and Canada.

Mr. L. L. Jones who very capably assisted in the instruction work during short course, Mr. K. D. Van Wagenen who acted as superintendent of the college poultry plant and Mr. M. E. Dickson who assisted in lecture and judging work on the extension circuit, deserve worthy comment for their efficient services.

It is hoped in another year we may have more assistance on the instructional staff in order to better handle the classes and to respond to calls from those who desire department services throughout the state.

Respectfully submitted,

J. O. LINTON,

Instructor in Poultry Husbandry.

East Lansing, June 30, 1912.

REPORT OF THE DEPARTMENT OF FORESTRY.

To the President:

I herewith present my report as Professor of Forestry for the year ending June 30, 1912.

COURSE OF STUDY.

The course as set forth in the college catalog for 1910-11 was followed throughout.

The enrollment of students with class work in comparison with other years, is as follows:

Term.	1908-9.	1909-10.	1910-11.	1911-12.
Summer	19	24	24	13
Fall	66	97	115	86
Winter	89	89	111	124
Spring	131	172	345	280
Total	305	382	595	503

Lectures were also given to the short course students.

1912 SUMMER TERM.

Owing to the termination of the trustship of the estate of David Ward and the division of the forest holdings among the several heirs, the location of the forestry camp was transferred from Crawford county to Charlevoix county on the holdings of the Boyne City Lumber Company.

The camp is thoroughly equipped and located adjacent to active modern logging operations on a large scale.

The courses are given according to the following periods:

Wednesday, June 19th–Tuesday, June 25th. Field Methods—Instructor Gilson.

Wednesday, June 26th–Wednesday, July 10th. Surveying—Assistant Professor Wendt.

Thursday, July 11th–Thursday, July 18th. Forest Types—Assistant Professor Sanford.

Friday, July 19th–Monday, July 22nd. Entomology — Professor Pettit.

Tuesday, July 23rd–Saturday, August 10th. Forest Mensuration—Professor Baker.

The hearty co-operation of Mr. W. C. Ward of Orchard Lake, Michigan, and Mr. W. H. White of the Boyne City Lumber Company, has made it possible to locate the forestry camps adjacent to active logging operations which is so essential to the best conduct of the work.

The field work in lumbering was carried on during December, 1911, on the holdings of the Freeman Smith Lumber Company of Millville, Arkansas.

FOREST EXTENSION.

The following tree stock was sent out from the forestry nursery during the spring 1912:

Stock shipped during spring, 1912.

Name.	Address.	Stock.
Anderson, A. C	East Lansing, Mich	1 White Cedar 3½ feet.
Baden, P. T	'Tic Society, East Lansing, Mich.	1 Red Pine, 4 Norway Spruce.
Baker, L. H	East Lansing, Mich	1 Norway Spruce.
Barrows, W. W	Hart, Mich	10 American Elm. 20 Black Walnut. 20 Silver Maple.
Birnbaum, J. W	Cleveland, Ohio Shipped to Northport, Mich.	1,000 Norway Spruce.
Bowen, Harvey Replacement.	Hoopston, Ill Shipped to Marlette, Mich.	3,000 White Pine.
Branch, Rev. E. E	340 E. Washington St., Ionia, Mich	100 Red Oak. 100 Silver Maple. 100 Black Locust.
Brewster, D. R Gov. Exchange.	Priest River Experiment Station, Idaho	115 White Pine. 115 Red Oak. 115 Black Walnut. 30 Sugar Maple. 30 Red Pine. 30 Black Locust. 30 Shellbark Hickory. 30 Pignut Hickory.
Brigham & Sons, G. A	Buckley, Mich	500 White Ash. 500 Black Cherry. 1,000 Black Walnut. 500 Butternut. 500 Red Oak. 500 Silver Maple. 500 Hard Maple. 1,000 Osage Orange.
Brockway, Geo	Homer, Mich	1,000 Black Locusts.
Brown, E. L	Schoolcraft, Mich	250 White Pine trans. 200 Norway Spruce. 100 White Cedar. 150 Butternut. 100 Black Walnut. 500 Black Locust.
Cameron, Roderick	Shabbona, Mich	1,000 Norway Spruce. 1,000 Butternut.
Case, Leland B	155 Boston Blvd., Detroit, Mich	500 White Cedar. 500 West. Yellow Pine. 500 Red Oak. 500 Black Cherry.
Clark, H. G	Grass Lake, Mich	100 Norway Spruce.

Stock shipped during spring, 1912.—Continued.

Name.	Address.	Stock.
Crill, J. E.	Lansing, Mich.	40 Norway Spruce.
Day, F. E.	Climax, Mich	2,500 Black Locust.
Dey, H. W.	Springport, Mich	500 Norway Spruce.
Evans, Earl E.	White Cloud, Mich.	1,000 White Pine.
Fairchilds, Irvin	Constantine, Mich	100 Norway Spruce.
Fort Valley Experiment Sta. Gov. Exchange.	Flagstaff, Ariz	100 Norway Spruce. 150 White Pine.
Garfield, Chas. W. Arbor Day Planting.	Grand Rapids, Mich	100 White Pine. 200 Norway Spruce. 110 Red Cedar. 10 West. Yellow Pine. 500 Butternut. 1,000 Osage Orange. 500 Black Locust.
Garlock, C. A.	Called for	30 Norway Spruce. 10 White Cedar. 24 White Pine.
Giddings, Mark	R. No. 2, Fife Lake, Mich	1,000 White Pine.
Giem, Ross N.	719 Church St., Kalamazoo, Mich.	125 White Pine. 25 Norway Pine. 115 Norway Spruce. 15 Black Locust. 10 Black Walnut.
Gitchell, James	Hudsonville, Mich	110 White Pine. 100 Norway Spruce. 100 Black Walnut. 400 Hard Maple.
Graham, R. D.	Grand Rapids, Mich	500 Norway Spruce. 500 White Ash. 500 Black Cherry. 100 Black Walnut. 200 Hard Maple. 200 Red Oak. 25 American Chestnut.
Grant, Roland B.	Lawrence, Mich	2,000 White Pine. 500 Norway Spruce.
Gregory, A. D.	R. D. No. 3, Ionia, Mich	2 Norway Spruce, 2 feet. 10 Norway Spruce, tran.

Stock shipped during spring, 1912.—Continued.

Name.	Address.	Stock.
Griffith, M. J.	R. No. 4, Melvin, Mich.	1,000 Silver Maple. 200 Hard Maple.
Hall, Fred T.	R. F. D., Greenfield, Mich.	500 Norway Spruce, tran.
Halligan, C. P.	East Lansing, Mich.	8 Norway Spruce. 4 Norway Pine.
Harger, Mark	Orchard Lake, Mich.	500 White Pine. 1,000 Hard Maple. 500 Black Locust.
Harrison, C. S.	East Lansing, Mich.	275 Yellow Car. Poplar.
Haywood, Hiram S.	Croswell, Mich.	100 White Ash. 100 Black Walnut. 200 Hard Maple. 85 Black Cherry. 200 Hard Maple.
Henry, Donald	R. No. 1, Shabbona, Mich.	100 Norway Spruce. 100 White Pine.
Hewitt, Arthur J.	Avoca, St. Clair Co., Mich.	500 Hard Maple Seedlings.
Holcomb, Wm.	Linden, Mich.	500 Black Locust.
Hoover, Joseph	R. No. 4, Box 54, Ionia, Mich.	50 White Ash. 50 Hard Maple. 100 Osage Orange. 50 Black Locust. 50 Silver Maple.
Horticultural Dept. Transferred.	College. Trees 3 to 6 feet high for Campus planting.	30 Norway Spruce. 8 Norway Pine. 15 Red Pine. 98 Red Cedar. 50 White Cedar.
Jensen, A. C.	East Lansing, Mich.	125 White Cedar.
Krieger, Wm.	Lansing, Mich.	2,000 Norway Spruce.
Lautner, C. S.	Traverse City, Mich.	200 Norway Spruce.
Leslie, A. M.	201 Main St., Evanston, Ill. Shipped to Northport, Mich.	12 Black Walnut. 12 Butternut. 12 Bitternut Hickory.

Stock shipped during spring, 1912.—Continued.

Name.	Address.	Stock.
Linton, W. S	Saginaw, Mich	1,000 Black Walnut.
Lindsay	East Lansing, Mich. Experiment Station.	1 Norway Spruce. 1 Basswood.
Magers, S. D	Northern State Normal, Marquette, Mich	50 White Pine. 50 Norway Spruce. 50 White Ash. 50 Black Cherry. 50 Black Walnut. 50 Butternut. 50 Bitternut Hick. 50 Red Oak. 100 Hard Maple. 25 Osage Orange. 25 Black Locust.
Martin, John B	98 Monroe St. Grand Rapids, Mich	1,000 White Pine. 1,000 White Ash. 1,000 Black Cherry. 1,000 Black Walnut. 1,000 Red Oak. 1,000 Silver Maple. 1,000 Hard Maple. 1,000 Black Locust.
McCrimmon, Roy S	South Haven, Mich	100 Norway Spruce. 50 White Ash. 200 Silver Maple. 100 Hard Maple.
Mentor Nurseries	Mentor, Ohio	2,000 White Pine.
Morley, Howard	Cedar Springs, Mich	1,000 White Pine.
Murbach, H. J	Riga, Mich	100 White Pine. 100 Norway Spruce. 100 Black Cherry. 100 Red Oak. 100 Hard Maple. 100 Black Locust.
Nagler, A. F	South Haven, Mich	200 Black Walnut. 100 Butternut.
Neff, J. S	Elsie, Mich	150 Black Locust.
N. Y. State College of Forestry	Syracuse, N. Y	1,000 Black Cherry. 1,000 Butternut. 1,000 Bitternut Hick. 1,000 Hard Maple. 1,000 Osage Orange.
Peck, L. E	Coopersville, Mich	200 Black Locust.

Stock shipped during spring, 1912.—Continued.

Name.	Address.	Stock.
Pennsylvania State College	State College, Pa	1,000 Norway Spruce. 1,000 Black Cherry. 1,000 Hard Maple.
Peterson, Oscar H	R. No. 1 Box 37, Northport Mich.	200 White Ash.
Profit, James	R. No. 1, Cass City, Mich	1,000 Norway Spruce.
Pulsifer, E. S	R. No. 1, Benton Harbor, Mich	100 Norway Spruce.
Rasmussen, R. J	Marlette, Mich	500 Norway Spruce. 1,000 Hard Maple.
Rayburn, Robt. H	Alpena, Mich	1,000 White Pine. 100 Black Walnut.
Richards, L. R	Howell, Mich	1,000 Black Locust.
Simonds & Co., O. C	1101 Buena Ave., Chicago, Ill... Ship to Fennville, Mich.	1,000 Osage Orange. 1,000 White Pine, trans. 1,000 White Pine seedlings.
Skeels, Dorr Gov. Exchange.	Libby, Montana	10,000 White Pine. 500 White Ash. 2,000 Red Oak. 1,000 Hard Maple. 500 Osage Orange. 500 Black Locust. 2,000 Carolina Poplar.
Smith, Wm. J	Saginaw, Mich Ship to Birch Run, Mich.	250 Norway Spruce. 50 White Cedar.
Stanton Forestry Assn	Stanton, Mich	250 Black Walnut. 75 Red Oak. 50 Norway Spruce. 50 White Cedar. 50 White Ash.
Stock, John	Metamora, Mich	100 Norway Spruce.
Stout, A. G	R. No. 3, South Haven, Mich	1,000 Black Locust.
Stover, A. Q	Clifford, Mich	225 Norway Spruce. 50 Black Walnut. 50 Red Oak. 50 Silver Maple.
Stroebel, John	Saginaw, W. S., Mich	1,000 White Pine. 500 Norway Spruce.

Stock shipped during the spring, 1912.—Concluded.

Name.	Address.	Stock.
Taft, L. R.	East Lansing, Mich.	500 Norway Spruce.
Teel, H. C.	Lansing, Mich.	12 Norway Spruce 4ft.
True, Geo. A.	Armada, Mich.	500 White Pine. 100 Red Oak. 100 Black Cherry. 1,000 White Ash.
Tyler, C. A. Demonstration work.	Coldwater, Mich.	1 Red Oak. 1 Black Locust. 1 Carolina Poplar.
Vining, C. W.	Lakeview, Mich.	100 White Pine. 1,000 Black Locust.
Walcott, Horace H.	Coopersville, Mich.	1,000 Hard Maple.
Walter, Mabel E. Arbor Day Planting.	Mayfield, Mich.	10 White Pine. 10 Black Walnut. 10 White Ash. 10 Carolina Poplar. 10 Hard Maple.
Watkins, Hon. L. Whitney.	Manchester, Mich.	1,000 Black Locust.
Wheeler, W. J.	Mt. Pleasant, Mich.	3,000 Black Locust. 1,500 Hard Maple. 500 Walnut.
Wiegand, Frank J.	970 E. Canfield Ave., Detroit, Mich.	750 White Pine. 750 Norway Spruce. 500 White Ash. 1,000 Hard Maple. 100 Yellow Pine. 1,000 Black Locust.
Wilcox, Mrs. M. S.	Saginaw, Mich.	100 White Pine.
Wilmarth, L. T.	Grand Rapids, Mich.	750 Hard Maple.
Wilson, R. H.	Holt, Mich.	100 Norway Spruce. 100 Black Locust.
Wood, P. J.	Melvin, Mich.	50 Norway Spruce. 200 Black Walnut. 50 Red Oak. 100 Hard Maple.

Comparison of stock shipped by years is as follows:

	1910.	1911.	1912.
Stock shipped	322,167	310,132	100,107

Eight thousand circular letters were issued during February setting forth the tree stock on hand at the following prices:

White Pine seedlings, 3 yrs. old, 6 to 9 inches high, per M.	$3 00
White Pine, once transplanted, 8 to 12 inches high, per M.	4 50
Norway Spruce seedlings, 3 yrs. old, 6 to 9 inches high, per M.	3 00
Norway Spruce, once transplanted, 15 to 20 inches high, per M.	10 00
White Cedar, once transplanted, 8 to 12 inches high, per M.	10 00
Western Yellow Pine, once transplanted, 12 to 18 inches high, per M.	5 00
White Ash, once transplanted, 2 to 3 feet high, per M.	5 00
Black Cherry seedlings, 10 to 15 inches high, per M.	3 00
Black Walnut seedlings, 1 to 2 feet high, per M.	5 00
Butternut seedlings, 12 to 18 inches high, per M.	4 00
Bitternut Hickory seedlings, 6 to 10 inches high, per M.	4 00
Red Oak seedlings, 2 to 3 feet high, per M.	4 00
Silver Maple seedlings, 2 to 3 feet high, per M.	5 00
Hard Maple seedlings, 12 to 18 inches high, per M.	3 00
Osage Orange seedlings, 2 to 3 feet high, per M.	2 00
Black Locust seedlings, 1 to 2 feet high, per M.	3 00

Circular No. 7, "The Michigan Woodlot," was issued by the Experiment Station.

Assistant Professor Sanford with two student assistants is now making a forest survey of three typical townships in each of the three counties, Ionia, Oakland and Cass.

Instructor I. W. Gilson is making observations on the basket willow industry in the state.

There is now on hand in the forest nursery, in nursery rows and seed beds 183,771 conifers and 1,085,806 broad leaved trees. The nursery is well stocked and amply able to furnish any species adapted to forest planting in this state in large quantities.

COLLECTION OF WOODS.

The department wishes to acknowledge the thoughtful courtesy of Mr. W. C. Ward of Orchard Lake, Michigan, in presenting the department with a large and very valuable collection of foreign and native woods which will add greatly to the facilities for the work in the study of woods and their identification.

The history of the collection is interesting in Mr. Ward's words:

"Many years ago, Mr. Michael Engleman, one of Michigan's foremost lumbermen, residing at Manistee, collected samples of a great many of the different kinds of wood growing in different countries. Some years after his death, this collection was presented to me by his daughters, he having no sons. As I shall retire from the lumber business shortly, it has occurred to me that the same ought to be under the custody of some institution that might take interest in it to such an extent as the

collection in question would merit. With this in view, I have decided to offer this collection to the Forestry department of the Michigan Agricultural College."

Represented in this collection are 150 species besides some duplicates and unnamed specimens.

During the past year 2,107 letters were sent out from this department.

Respectfully submitted,

J. FRED BAKER,
Professor of Forestry.

East Lansing, June 30, 1912.

REPORT OF THE DEPARTMENT OF AGRICULTURAL EDUCATION.

President J. L. Snyder:

My Dear Sir—I herewith submit a brief report of my labors during the year ending July 1, 1912.

1. Teaching.—I have taught the classes in Pedagogics during the year, one section for the women, for Pedagogy I, II and III, and two sections for the men for Pedagogy IV, V and VI, making 15 hours per week. It seemed best to give two sections of the work for the men. Twenty-six women took the courses, and 16 men in the first section and 31 in the second section, making 47 men in all. The work for the women has consisted of Psychology, School Administration and History of Education. During the winter term I arranged with the superintendent of the Lansing schools for members of the senior class, both men and women, to visit the grades and the high school at different times, and observe the methods of work, apparatus, arrangement of laboratories and laboratory equipment. During the spring term the women were given opportunity for practice teaching in Domestic Science and Domestic Art in the 7th and 8th grades. The men had the same opportunity for observation in the Lansing schools, and all of them who expected to teach visited one or more of the high schools where agriculture is being taught, thus coming in contact directly with the practical side of the work.

The work for the men has consisted of Psychology, School Administration, and during the spring term a course in Agricultural Pedagogy, consisting of the History of Secondary Agriculture, methods of teaching, organization of courses, laboratory equipment, field work and the special application of pedagogical principles to agricultural instruction.

2. High Schools.—During the year, regular four-year courses in agriculture have been given in whole or in part in 14 high schools. The instruction has been presented by graduates of this institution. In addition to these schools 15 other high schools have given some instruction in agriculture, usually in the 10th grade, and the classes were taught either by the superintendent of schools or by the science teacher.

For the ensuing year 8 schools have already arranged for the introduction of courses in agriculture, viz., Bangor, Croswell, Fremont, Hart, Hudson, Manistee, Ovid and Saginaw, and in addition to these several

other schools are considering introducing the courses, but I am unable to report definitely at this time. At Grand Ledge and Charlevoix the science instruction is given by one of our agriculture graduates, and some agricultural instruction will be given preparatory to the introduction of full courses. So I think we may safely include these two in our list. This will make 22 schools giving regular courses, and probably four others will be established before September. Two schools, viz., Northville and Manchester, will discontinue the courses in agriculture because of lack of local support.

I have visited the several high schools where agriculture was presented from two to three times during the year, and made such suggestions as seemed necessary for the improvement of the work. I have found that generally the people are deeply interested in the courses, and the work is not only valuable in itself, but has a very strong bearing upon the other work of the high school, tending to strengthen it and give definite purpose to the general work of the students. The course of study prepared and recommended by this department has been followed in all the schools.

3. Visitation.—In addition to visiting the high schools where agriculture is taught, I have visited about 75 other schools during the year, and have given addresses to high school students and met with boards of education to discuss the matter of agricultural instruction. I have also visited a number of schools with reference to their being placed on our accredited list. Nearly all of the reputable high schools of the state are now upon our list. I have also visited a number of granges and farmers' clubs and given addresses along the line of agricultural education.

4. Extension Courses.—During the winter months, in connection with each of the high schools presenting agricultural courses, we conducted a series of schools, or lectures, for the farmers of the community. The lectures were usually given on Saturday afternoon, and were well attended. As nearly as I can estimate, about 1,200 farmers attended these lectures. In addition to these we conducted a one week's short course in connection with three high schools—Hillsdale, Union City and Watervliet.

The one-day lectures are excellent, but it seemed to us that more extensive work could be done in a regular school, and, therefore, for these one week courses we selected Mr. Raven, Mr. Jeffery and Mr. Shoesmith to take up in each of these places two different lines of work for the week. Mr. Raven presented the subject of live stock, and Mr. Jeffery and Mr. Shoesmith the subjects of soils and crops.

The attendance was as follows: 50 at Watervliet, 130 at Union City, and 140 at Hillsdale. Intense interest was manifested and the farmers passed strong resolutions urging that this plan be continued. We suggest, therefore, that the one-week short course plan should be followed another year in connection with each of the high schools presenting agriculture. We believe this will prove a very valuable addition to the general extension work of the college, and will strengthen, also, the local high school work.

5. Institutes.—I have conducted eight teachers' institutes during the year, and have given considerable time to farmers' institutes. It does not occur to me, however, that the time spent in farmers' institutes

is of any very great value, either to the institution or to our general work. The teachers' institutes are largely attended, and in each case I gave special lectures and instruction on the subject of agriculture adapted to rural school instruction.

6. Publications.—During the year we have published a pamphlet giving the high school course of study in agriculture, and a report of the agricultural instruction during the year 1911, and another pamphlet on Projects in Agriculture for Rural Schools. The latter pamphlet will be distributed by the State Superintendent of Public Instruction among the rural schools of the state. There has been an insistent demand for such a publication, and I trust that this will supply the needed information as to means and methods of elementary instruction.

7. Teachers.—The registration and location of teachers prepared in this institution occupies a large amount of time, and causes almost endless correspondence. Sixteen women out of the graduating class have secured good positions for another year. Nearly all of them will teach domestic science and art. Some of them will undertake other high school subjects. I find that superintendents are beginning to look to our institution for teachers of these special subjects, but the number of schools which present Home Economics is so small that the opportunity for teaching is rather limited. Hence, many of our young women are forced to take up other subjects if they desire to teach.

Sixteen men have accepted places to teach agriculture in Michigan during the ensuing year, and it is probable that several more will find places. In addition to these, several have secured positions in other states: Mr. Sorenson at Fresno, Cal.; Mr. Bovay at Coleraine, Minn.; Mr. Jurgens at Leroy, Minn.; Mr. Ryther near Rochester, N. Y.; Mr. DeGraff at Griegsville, N. Y.; Mr. Adams at Elyria, Ohio, and Mr. Van Wagenen at Cloquet, Minn. We have had many calls from other states for teachers of agriculture which we have been unable to supply.

About half of the young men taking the course in Pedagogy were doing so as a general culture course, as they did not intend to teach. In fact, I have had a hard time to induce some of the men whom I desired to have teach, to undertake the work. In addition to those who teach in this country, Mr. Taylor and Mr. Tibbs will be supervisors of agriculture in the Philippines.

8. State Society for the Promotion of Agricultural Education.—In 1909 we organized a State Society for the Promotion of Agricultural Education, and have held annual meetings of this society. The last meeting was held on April 15th, in the Agricultural Building. We had a large attendance of agricultural teachers and superintendents, in addition to members of the faculty and students of the college. Papers and discussions were given by Mr. McVittie, Dean Shaw, Superintendent Warriner, Mr. Chapin, Mr. Langdon and Mr. Nash. The following officers were elected for the ensuing year: President, R. A. Turner, Hillsdale; Vice President, C. S. Langdon, Watervliet; Secretary, J. W. Chapin, North Adams, and Corresponding Secretary, W. H. French.

It was voted to send delegates from the Michigan association to the National Society for the Promotion of Agricultural Education which will meet in Atlanta, Ga., November 12th. We believe that this organization will be of great value not only to the public schools of the state, but to the Agricultural College as well.

9. Extension Reading Course.—This has been the fourth year of the Extension Reading Course. The enrollment has varied from 140 to 310. During the current year we have enrolled 182 readers. Of this number about 40 have completed the reading and submitted written reports. I presume that all of the people have read the books, but have not found it convenient to make out the written report. Under the plan of organization, when an individual has completed the four year course we are to issue a diploma, and six such diplomas have been issued to the following persons: James A. Elliott, Clerk Board of Trade, Duluth, Minn.; Bertha M. Warner, Plymouth, Mich.; Mrs. Eva Felton, East Lansing, Mich.; Arthur J. Adams, Shelby, Mich.; Mrs. Carrie T. Meacham, Union, Mich.

I have received a large number of letters from those who have pursued the reading, and all seem to be pleased with the work and to desire its continuance. I would suggest that a three-year course be arranged instead of the four-year course, and that instead of holding strictly to agriculture and home economics subjects that the course be broadened by including subjects of general culture. This course seems to meet the needs of certain people, and as it costs us comparatively little, it seems to me advisable to recommend its continuance, at least for the present.

We have many inquiries in regard to a "correspondence course," but it does not seem advisable to me to institute a correspondence course in agriculture. It is my opinion that the regular extension work of the college in the several agricultural lines, together with the several extension features of the high school work will ultimately prove of much more value, and will bring the agricultural subjects more directly to the people than could a correspondence course. If a correspondence course were instituted it would necessitate the employment of special persons to prepare questions, look over papers, and possibly visit the people in order to direct the work and make it valuable. And as I stated, it does not seem to me to be advisable.

10. Employment Agency.—At the opening of the college year in 1910, a committee was appointed consisting of Professor Kedzie and myself, to consider the advisability of establishing an employment agency through which we might assist students in securing work, and thus keep them in college. Mr. Robert E. Loree was selected to take charge of the work, and he has been extremely successful in its management. During the current year about 100 students have enrolled at different times and they have been successful in securing employment off the grounds as well as on the grounds. So far as Mr. Loree's report shows, the students have been satisfied with the management, and with the character of the work and the pay for the same. They have received from 15 cents to 20 cents an hour for their labor.

The committee recommends that Mr. Loree be employed to take charge of this work the ensuing college year. He has indicated to the committee that he will be willing to direct it. I believe that this plan will prove more and more helpful as it becomes better understood by the students.

The work done by students has included pruning, grafting, planting potatoes, preparation of gardens, house cleaning, fence building, picking fruit, etc.

11. Agriculture in Rural Schools.—During the year I have counseled with many county commissioners of schools in regard to instruction in agriculture. I have prepared a course of study which is to be printed by the Department of Public Instruction in the State Course of Study for rural schools. The course in general includes nature study in the first four grades, gardening in the 5th and 6th grades, and instruction by means of textbooks and out of door exercises for the 7th and 8th grades. I sent out a questionaire to each county commissioner asking for information as to what has been done already along these lines. The reports from 44 counties show that some instruction in agriculture is given in 1,135 schools, and in 26 counties boys' corn-growing clubs have been organized.

In addition to the work directed in these corn contests by the county commissioners, the county Y. M. C. A. in five counties conducted contests. In addition to these, in a few counties potato contests are in progress for the current year.

These reports show, also, that in 10 villages and schools regular instruction in school gardening is given, with a garden exhibit in the fall.

Thus it will be seen that considerable interest is being manifested on the part of the patrons and children of rural schools, and the county commissioners of schools are alive to the benefits which can be derived from the elementary instruction which has already been planned. In this connection it may be said that the teachers of rural schools who have received their training in our State Normal Schools or in the County Normal Training Classes, have received some definite instruction along these lines, and are thus prepared to advise and direct intelligent work on the part of the children.

It occurs to me that if we could call a meeting of the county commissioners of schools at the college, at some time during the winter season, we might give them some helps and some suggestions that would be of value, especially along the line of conducting boys' and girls' clubs in agricultural activities.

Respectfully submitted,

WALTER H. FRENCH,

Professor of Agricultural Education.

East Lansing, June 30, 1912.

REPORT OF THE DEAN OF ENGINEERING.

Dr. J. L. Snyder, President Michigan Agricultural College:

Dear Sir—I present herewith my fifth annual report as Dean of Engineering, the same covering the fiscal year ending June 30, 1912.

The *personnel* of the departments of the Division of Engineering may be found by reference to the respective reports. There are 30 teachers of all grades in the division.

The *student enrollment* in engineering for the year is 453, being 28 less than last year, the shrinkage showing most in the freshman year. Simultaneously, the enrollment in the Division of Agriculture has noticeably increased. Inquiry reveals similar conditions in many other "land grant" colleges, and is partly at least due to the response to the agitation for improvement of rural life conditions and partly to the quietness in engineering fields prevalent for a few years past. Conditions in the latter respect have materially improved of late. The members of the present graduating class have been placed without difficulty and at salaries or wages noticeably higher than in any previous year in my observation of the past 24 years.

The *graduating class* in engineering numbers 54, and professional engineering degrees were granted to 5 men, as follows:

Bennett, W. C., '05, C. E.
Ellis, G. H., '07, C. E.
Ford, C. C., '05, M. E.
Mastenbrook, H. J., '06, M. E.
Poole, J. E., '06, M. E.

The *revised course of study* which has been fully effective during the year, is satisfactory and promises better work by students and teachers. An administrative difficulty exists in the unbalance of the teaching burdens of the departments in the several terms of the year, due in part to the requirements of other divisions of the college, whose students receive instruction in the engineering division and in part to lack of symmetry in the engineering program itself, both of which causes can not as yet be eliminated or modified.

The *relations* of the engineering division to the other divisions of the college are cordial and characterized by the co-operative spirit.

I think, however, that the *representation* of the division in the *general faculty* should be increased, particularly as the divisional faculties have not proved the right to be considered as factors in the college administration and executive system.

I believe further that the members of the general faculty are not informed or consulted in matters of moment to the college as a whole, as they should be, to secure the best spirit and mutual understanding between the members of the teaching force of all grades.

The *student spirit* in the division has been excellent. The Engineer-

ing Society has been very active and has held meetings of value. The society is particularly to be commended for its zeal and success in securing non-resident lecturers for its programs.

The movement of the *change of name*, which originated spontaneously within the student body, is based upon a deep-rooted feeling of students and alumni of the engineering course and is entitled to the careful consideration of the authorities. The writer is on record in favor of designating the college as the Michigan State College of Agriculture and Mechanic Arts.

The matter of *publicity* for the engineering work at the college should be given some attention if the college is to develop symmetrically and in the spirit of the Morrill Act.

The college offers excellent training in the foundations of engineering and this fact should be as well known and appreciated by its constituency as by its faculty, students, alumni and those who employ our graduates.

In my report of last year, and previously, I have discussed the *salary* question at length and invite again your attention to the matter, for the welfare of the whole college.

Respectfully submitted,
G. W. BISSELL,
Dean of Engineering.

East Lansing, June 30, 1912.

REPORT OF THE DEPARTMENT OF MECHANICAL ENGINEERING.

Dr. J. L. Snyder, President Michigan Agricultural College:

Dear Sir—I present herewith my report as Professor of Mechanical Engineering for the fiscal year ending June 30, 1912.

At the beginning of the college year, Mr. G. W. Hobbs who, during the preceding year, had been employed by the hour, was placed on the regular salary roll.

With this technical exception, no changes in the *personnel* of the department have been made since my last report. In the winter term, owing to light schedule in the Civil Engineering department, Mr. C. D. Curtiss and Mr. R. W. Powell of that department gave full and part time respectively to my department which had a very heavy program. It was necessary, also, to employ Messrs. Coplan and Keifer as student assistants for a few hours weekly to help carry the heavy teaching of the winter term.

The spring term program was rather light and Mr. J. L. Morse of my department carried one section of descriptive geometry for the Department of Drawing and Design.

The complete salaried teaching force of the department is as follows:

G. W. Bissell, Professor of Mechanical Engineering;

J. A. Polson, Assistant Professor of Mechanical Engineering, in charge of Engineering Laboratory;

E. J. Kunze, Assistant Professor of Mechanical Engineering, in charge of Machine Design and Shop Work;

J. L. Morse, Instructor in Machine Design;

G. W. Hobbs, Instructor in Engineering Laboratory;

E. A. Evans, Foreman-Instructor in Machine Shop;

A. P. Krentel, Foreman-Instructor in Pattern Shop;

E. C. Baker, Instructor in Foundry;

W. R. Holmes, Instructor in Forge Shop;

A. Smith, Instructor in Pattern Shop;

J. A. Neal, Instructor in Machine Shop.

In addition to the above and those of another department and student assistants already mentioned, Mr. E. C. Crawford as Laboratory Engineer, and Miss C. B. Purcell as Clerk, have continued their connections with the department.

I take this opportunity to thank all members of my staff for the services rendered and results achieved.

The following graduating theses were done in the department during the year:

Anderson, V. G. Hammond, H. L.	Test of Hot-water Heating System.
Barrows, F. L. O'Dell, G. M.	Case-hardening of Cold-rolled Steel.
Bender, E. R.	Heating and Ventilating for a Church.
Benner, L. O. Groothius, H. Schneider, H. W. Tenkonohy, R. J.	Centrifugal Pump—Design, Construction and Test.
Bennett, D M. Knapp, C. W.	Test on a Hot-Blast Heating System.
Bone, H. E. Kane, F. H.	Reinforcement of Cast-Iron Machine Members.
Conway, G. F Holden, J. A.	Corliss Engine Tests.
Culver, E. G. VanMeter, M.	Design of 250-lb. Steam Hammer.
Hall, S. L. Shuart, A. B. Wadd, R. J.	Efficiency Tests of a Gas Engine.
Hotchin, E. E. Iddles, A.	Power Gas Apparatus.
Jonas, J. F. White, G. A.	Coal Handling and Storage for Retail Yard.

Below in Tables I, II and III, is given the class work for the year. A tabular exhibit of the work of this department follows.

Respectfully submitted,

G. W. BISSELL,

Professor of Mechanical Engineering.

East Lansing June 30, 1912.

TABLE I.

Classwork of Department of Mechanical Engineering, fall term, 1911.

Class.	Subject.	No. of course.	Teacher.	Hours per week each student.	No. of students enrolled	Student hours per week.
4-year freshmen	Wood shop	2 a	Mr. Krentel, Mr. Smith	6	107	642
5-year freshmen	Wood shop	2 p	Mr. Krentel, Mr. Smith	4	22	88
4-year and 5-year Freshmen, Sophmores	Forge shop	2 d	Mr. Holmes	6	78	468
Sophomores	Foundry	2 f	Mr. Baker	6	56	336
Sophomores	Empirical design	6 a	Mr. Morse, Student assts	6	113	678
Sophomores, Juniors	Machine shop	2 h	Mr. Evans, Mr. Neal	6	74	444
Juniors, Seniors	Machine shop	2 k	Mr. Evans, Mr. Neal	6	30	180
Juniors	Machine design	6 c	Prof. Kunze, Mr. Morse	3	45	135
Juniors	Metallurgy	11 a	Prof. Polson, Prof. Kunze, Mr. Morse, Mr. Hobbs	2	81	162
Seniors	Steam engine design	8 b	Prof. Kunze	6	27	162
Seniors	Engineering, Laboratory	13 c	Prof. Polson, Mr. Hobbs	8	55	440
Seniors	Heating and Ventilation	18 a	Prof. Bissell	3	32	96
Seniors	Costs, Accounting, etc.	18 c	Prof. Bissell	2	54	108
Totals					774	3,939

TABLE II.

Classwork of Department of Mechanical Engineering, winter term, 1912.

Class.	Subject.	No. of course.	Teacher.	Hours per week each student.	No. of students enrolled.	Student hours per week.
4-year freshmen	Wood shop	2 b	Mr. Krentel, Mr. Smith	6	102	612
5-year freshmen	Wood shop	2	Mr. Krentel, Mr. Smith	4	23	92
4-year and 5-year freshmen	Elements of Engineering	1	Prof. Bissell	2	127	254
4-year and 5-year Freshmen, sophomores	Forge shop	2 c	Mr. Holmes	6	72	432
Sophomores	Foundry	2 f	Mr. Baker	6	56	336
Sophomores	Kinematics	6 b	Prof. Kunze, Mr. Curtiss, Student assistants	5	91	455
Sophomores	Machine shop	2 i	Mr. Evans, Mr. Neal	6	76	456
Juniors	Engines and Boilers	7 a	Prof. Kunze, Mr. Morse, Mr. Powell	3	50	150
Juniors	Machine design	6 d	Mr. Morse	6	54	204
Juniors	Engineering laboratory	13 a	Prof. Polson, Mr. Hobbs, Mr. Curtiss	4	70	280
Seniors	Engineering laboratory	13 d	Prof. Polson, Mr. Hobbs	8	29	232
Seniors	Machine shop	2 l	Mr. Evans, Mr. Neal	6	11	66
Seniors	Works, Management	5 a	Prof. Kunze	3	40	120
Seniors	Jig and Fixture Design	6 e	Prof. Kunze	8	23	184
Seniors	Power Station Design	18 b	Prof. Bissell	7	29	203
Totals					833	4,076

TABLE III.

Classwork of Department of Mechanical Engineering, spring term, 1912.

Class.	Subject.	No. of course.	Teacher.	Hours per week each student.	No. of students enrolled.	Student hours per week.
4-year freshmen	Wood shop	2 c	Mr. Krentel. Mr. Smith	6	94	564
4-year and 5-year freshmen	Descriptive Geometry	5 ab	Mr. Morse	9	27	243
4-year and 5-year Freshmen, sophomores	Foundry	2 g	Mr. Baker	6	53	318
Sophomores	Forge shop	2 c	Mr. Holmes	6	50	300
Sophomores Juniors	Machine shop	2 j	Mr. Evans. Mr. Neal	6	59	354
Juniors	Thermodynamics	17 a	Prof. Bissell. Prof. Polson. Prof. Kunze	4	61	244
Juniors	Engineering laboratory	13 b	Prof. Polson. Mr. Hobbs	4	57	228
Juniors	Steam engine design	8 a	Mr. Morse	4	31	124
Seniors	Gas power engineering	8 c	Prof. Kunze	3	39	117
Seniors	Machine tool design	6 f	Prof. Kunze	6	5	30
Seniors	History of engineering	18 d	Prof. Bissell	2	51	102
Seniors	Thesis	19 a	Prof. Bissell. Prof. Polson. Prof. Kunze	20	22	440
Totals					549	3,064

REPORT OF THE DEPARTMENT OF CIVIL ENGINEERING.

President J. L. Snyder:

Dear Sir—A review of the work of this department for the year 1911-1912 leaves little to be desired in matters of zealous industry and harmony among the members of the teaching staff. In results obtained the year will compare favorably with any earlier year. Indeed I am of the opinion that the department attained the high water mark of efficiency.

At the close of last year's work there were good grounds for apprehension that we should not be able to present so satisfactory a report at this time. Of the 8 teachers engaged with us in the spring term of 1911, 4 left for other fields of activity. Four new appointments were made before the beginning of the fall term and the fact that just half our staff was made up of new men at this time was sufficient excuse for some misgiving.

It is therefore with the greatest pleasure that I commend the efforts of all the teachers of this department, both old and new, to promote the high measure of departmental achievement which has made possible the statement of my opening paragraph.

At the beginning of the fall term our departmental staff included the following teachers whose names are given in order of seniority of appointment:

H. K. Vedder, C. E., Professor of Civil Engineering;
W. B. Wendt, B. C. E., Assistant Professor of Civil Engineering;
H. E. Marsh, B. S., Instructor in Civil Engineering;
A. M. Ockerblad, B. S. in C. E., Instructor in Civil Engineering;
R. W. Powell, B. S., Instructor in Civil Engineering;
C. A. Melick, D. C. E., Assistant Professor of Civil Engineering;
E. D. Kingman, Ph. B., Instructor in Civil Engineering;
C. D. Curtiss, B. S., Instructor in Civil Engineering.

Two of those named above have resigned and will leave us with the close of this school year. Mr. H. E. Marsh will take up practical work in structural engineering and Mr. R. W. Powell has accepted an instructorship at Cornell University.

I wish to repeat my recommendation of last year that there be appointed an assistant whose chief duty shall be the care and inspection of our surveying instruments, field tools and laboratory equipment. I also recommend that the department be given the full time services of a stenographer to care for the constantly increasing work which falls to our share. I also suggest the rehabilitation of our astronomical observatory. This building contains a good telescope equatorially mounted and is supposed to furnish protection for this instrument. Some years ago vandals forced the door of the observatory and left open the sky shutter. This happened in the winter months and the elements injured the contents of the building almost to the point of destruction. Any plan that is adopted for putting our observatory again into commission must include the clearing away of a group of evergreens which have grown up about the building until they seriously interfere with telescopic observation.

As for many years past, I present herewith a tabulation showing the work of teaching carried out by this department during the year; it will answer questions of assignments, enrollment, class rooms occupied, size of sections and the like.

Class work of the Department of Civil Engineering for the college years 1911–1912.

Class.	Subject.	No. of course.	Teacher.	Classroom.	Hour of meeting.	No. hours per week.	No. of students in class.
Summer sch'l 1911. (2 weeks)							
Juniors.....	Surveying methods (class).	C.E. 2..	Prof. Wendt............	Sand Lake, Antrim County, Mich. .	....	11	24
Juniors.....	Surveying methods (field).	C.E 2..	Prof. Wendt............	Sand Lake, Antrim County, Mich.. .	....	38	24
Totals..	2 Sections..............					49	48
Fall term.							
Sophomores.	Surveying (class)........	C.E. 1a.	Mr. Ockerblad..........	302 Eng. Bldg....	1–2	2	23
Sophomores.	Surveying (class)........	C.E. 1a.	Mr. Ockerblad..........	302 Eng. Bldg....	3 4	2	28
Sophomores.	Surveying (field)........	C.E. 1a.	Mr. Powell, Mr. Curtiss...	....	8 10	2	45
Sophomores.	Surveying (class)........	C.E. 1a.	Mr. Curtiss.............	401 Eng. Bldg....	1–2	2	22
Sophomores.	Surveying (class)........	C.E. 1a.	Mr. Curtiss.............	120 Eng. Bldg....	3 4	2	24
Sophomores.	Surveying (field)........	C.E. 1a.	Mr. Ockerblad, Mr. Curtiss	....	1–3	2	52
Juniors.....	Surveying (class)........	C.E. 2..	Mr. Ockerblad..........	109 Eng. Bldg....	8–9	3	19
Juniors.....	Surveying (field)........	C.E. 2..	Mr. Ockerblad, Mr. Curtiss	109 Eng. Bldg....	8–10	4	19
Juniors.....	Mech. of Eng...........	C.E. 4a.	Prof. Wendt............	203 Eng. Bldg....	8–9	5	8
Juniors.....	Mech. of Eng...........	C.E. 4a.	Mr. Marsh..............	203 Eng. Bldg....	1–2	5	17
Juniors.....	Mech. of Eng...........	C.E. 4a.	Prof. Melick............	401 Eng. Bldg....	8–9	5	21
Juniors.....	Mech. of Eng...........	C.E. 4a.	Prof. Melick............	111 Eng. Bldg....	1 2	5	13
Juniors.....	Mech. of Eng...........	C.E. 4a.	Mr. Kingman...........	302 Eng. Bldg....	8 9	5	17
Juniors.....	Adv. Surveying (class)...	C.E. 6..	Prof. Wendt............	203 Eng. Bldg....	3 4	3	22
Juniors.....	Adv. Surveying (field)....	C.E. 6..	Prof. Melick, Mr. Marsh..	....	2–4	4	20
Juniors.....	Adv. Surveying (field)....	C.E. 6..	Prof. Melick, Mr. Powell..	....	10–12	4	20
Juniors.....	Adv. Surveying (class)...	C.E. 6..	Mr. Marsh..............	203 Eng. Bldg....	9–10	3	21
Juniors.....	Adv. Surveying (field)....	C.E. 6..	Mr. Marsh, Mr. Ockerblad	302 Eng. Bldg....	2–4	4	21
Juniors.....	Adv. Surveying (field)....	C.E. 6..	Mr. Marsh, Mr. Powell...	401 Eng. Bldg....	10–12	4	17
Juniors.....	Adv. Surveying (class)...	C.E. 6..	Mr. Kingman...........	302 Eng. Bldg....	9 10	3	21
Juniors.....	Adv. Surveying (class)...	C.E. 6..	Mr. Curtiss.............	401 Eng. Bldg....	4–5	3	15
Seniors.....	Graphic Statics.........	C.E. 4d.	Prof. Melick............	401 Eng. Bldg....	9–10	3	11
Seniors.....	Graphic Statics.........	C.E. 4d.	Mr. Marsh..............	111 Eng. Bldg....	8–9	3	15
Seniors.....	Hydraulics.............	C.E. 5..	Prof. Wendt............	203 Eng. Bldg....	11 12	5	29
Seniors.....	Hydraulics.............	C.E. 5..	Mr. Kingman...........	302 Eng. Bldg....	10–11	5	26
Seniors.....	Hydraulic Lab..........	C.E. 5a.	Prof. Wendt............	3 Eng. Bldg.	1–5	4	10
Seniors.....	Hydraulic Lab..........	C.E. 5a.	Prof. Wendt............	3 Eng. Bldg......	1 5	4	9
Seniors.....	Hydraulic Lab..........	C.E. 5a.	Mr. Kingman...........	3 Eng. Bldg......	1–5	4	7
Seniors.....	Hydraulic Lab..........	C.E. 5a.	Mr. Kingman...........	3 Eng. Bldg......	1 5	4	8
Seniors.....	Bridge Stresses..........	C.E. 8a.	Prof. Vedder............	111 Eng. Bldg....	9–10	3	10
Seniors.....	Bridge Stresses..........	C.E. 8a.	Prof. Vedder............	111 Eng. Bldg....	11–12	3	15
Seniors.....	Adv. Surveying.........	C.E. 6b.	Prof. Vedder............	111 Eng. Bldg....	11–12	1	15
Seniors.....	Adv. Surveying.........	C.E. 6b.	Prof. Vedder, Mr. Powell.	111 Eng. Bldg....	1–5	4	15
Seniors.....	Adv. Surveying.........	C.E. 6b.	Prof. Vedder............	111 Eng. Bldg....	8–9	1	15
Seniors.....	Adv. Surveying.........	C.E. 6b.	Prof. Vedder, Mr. Powell.	111 Eng. Bldg....	1–5	4	15
Totals..	36 sections.............	....	....	....	....	110	665

Class.	Subject.	No. of course.	Teacher.	Classroom.	Hour of meeting.	No. hours per week.	No. of students in class.
Winter term.							
Juniors.....	Agr. Eng..............	C.E. 3..	Prof. Vedder............	111 Eng. Bldg....	9–10	5	33
Juniors.....	Agr. Eng..............	C.E. 3..	Prof. Vedder............	111 Eng. Bldg....	10–11	2	17
Juniors.....	Mech. of Eng...........	C.E. 4b.	Mr. Ockerblad..........	203 Eng. Bldg....	8–9	5	18
Juniors.....	Mech. of Eng...........	C.E. 4b.	Mr. Ockerblad..........	203 Eng. Bldg....	1–2	5	14
Juniors.....	Mech. of Eng...........	C.E. 4b.	Mr. Powell.............	302 Eng. Bldg....	8–9	5	20
Juniors.....	Mech. of Eng...........	C.E. 4b.	Mr. Powell.............	302 Eng. Bldg....	1–2	5	15
Seniors.....	Bridge Design...........	C.E. 8b.	Prof. Melick............	304 Eng. Bldg....	10–12	8	12
Seniors.....	Bridge Design...........	C.E. 8b.	Mr. Marsh..............	306 Eng. Bldg....	10–12	8	13
Seniors.....	Mas'y and arches (lab)...	C.E. 9..	Prof. Wendt, Prof. Melick	111 Eng. Bldg....	3–5	4	14
Seniors.....	Mas'y and arches (rec.)...	C.E. 9..	Prof. Melick............	111 Eng. Bldg....	1–2	3	12
Seniors.....	Mas'y and arches (rec.)...	C.E. 9..	Prof. Wendt............	111 Eng. Bldg....	8–9	3	14
Seniors.....	Mas'y and arches (lab)...	C.E. 9..	Prof. Melick, Prof. Wendt.	111 Eng. Bldg....	10–12	4	12
					3–5	4	12
Seniors.....	Pavements.............	C.E. 10.	Mr. Kingman...........	111 Eng. Bldg....	3–4	2	10
Seniors.....	Pavements.............	C.E. 10.	Mr. Kingman...........	111 Eng. Bldg....	8–9	2	15
Seniors.....	Experimental Lab.......	C.E. 12.	Mr. Marsh, Mr. Kingman.	4 Eng. Bldg......	2–5	3	7
Seniors.....	Experimental Lab.......	C.E. 12.	Mr. Ockerblad..........	4 Eng. Bldg......	9–12		
					2–5	6	13
Seniors.....	Experimental Lab.......	C.E. 12.	Mr. Powell.............	106 Eng. Bldg....	9–12	5	13
					2–4		
Seniors.....	Experimental Lab.......	C.E. 12.	Mr. Kingman, Mr. Marsh.	106 Eng. Bldg....	2–5	3	7
Seniors.....	Water Supply, sewerage..	C.E. 15.	Prof. Wendt............	203 Eng. Bldg....	9–10	4	14
Seniors.....	Water supply, sewerage..	C.E. 15.	Mr. Kingman...........	302 Eng. Bldg....	9–10	4	11
Totals..	20 sections.............	....	....	....	....	86	284

Class.	Subject.	No. of course.	Teacher.	Classroom.	Hour of meeting	No. hours per week..	No. of students in class.
Spring term.							
Sophomores.	Surveying, leveling (f)....	C.E. 1b.	Mr. Ockerblad, Mr. Curtiss	....	1–3	4	34
Sophomores.	Surveying, leveling (f)....	C.E. 1b.	Prof. Wendt, Mr. Curtiss..	111 Eng. Bldg....	1–3	4	31
Sophomores.	Surveying, leveling (c)...	C.E. 1b.	Prof. Wendt............	203 Eng. Bldg....	3–4	2	31
Sophomores.	Surveying, leveling (c)...	C.E. 1b	Mr. Curtiss.............	111 Eng. Bldg....	9–10	2	27
Sophomores.	Surveying, leveling (f)....	C.E. 1b.	Mr. Marsh, Mr. Curtiss...	111 Eng. Bldg....	10–12	4	27
Sophomores.	Surveying, leveling (f)....	C.E. 1b.	Mr. Curtiss, Mr. Marsh ..	111 Eng. Bldg....	10–12	4	28
Sophomores.	Surveying, leveling (c)...	C.E. 1b.	Mr. Curtiss.............	111 Eng. Bldg....	9–10	2	28
Sophomores.	Surveying, leveling (c)...	C.E. 1b.	Prof. Wendt............	203 Eng. Bldg....	3–4	2	34
Sophomores.	Surveying methods (f)...	C.E. 2..	Prof. Wendt............	203 Eng. Bldg....	1–3	4	14
Sophomores.	Surveying methods (c)...	C.E. 2..	Prof. Wendt............	203 Eng. Bldg....	8–9	3	14
Juniors.....	Topog. surveying (c).....	C.E. 2a.	Prof. Wendt............	120 Eng. Bldg....	10–11	3	26
Juniors.....	Topog. surveying (f).....	C.E. 2a.	Prof. Wendt............	120 Eng. Bldg....	10–12	4	26
Juniors.....	Str. of materials.........	C.E. 4c.	Mr. Ockerblad..........	302 Eng. Bldg....	10–11	5	16
Juniors.....	Str. of materials.........	C.E. 4c.	Mr. Ockerblad..........	302 Eng. Bldg....	11–12	5	15
Juniors.....	Str. of materials.........	C.E. 4c.	Mr. Powell.............	302 Eng. Bldg....	1–2	5	16
Juniors.....	Str. of materials.........	C.E. 4c.	Mr. Powell.............	302 Eng. Bldg....	2–3	5	14
Juniors.....	Topog. mapping..........	C.E. 6a.	Mr. Marsh, Mr. Powell...	203 Eng. Bldg....	3–5	4	16
Juniors.....	Topog. mapping (c)......	C.E. 6a.	Mr. Marsh..............	203 Eng. Bldg....	4–5	2	16
Juniors.....	Topog. mapping (f)......	C.E. 6a.	Mr. Marsh, Mr. Ockerblad.	203 Eng. Bldg....	8–10	4	18
Juniors.....	Topog. mapping (c)......	C.E. 6a.	Mr. Marsh..............	203 Eng. Bldg....	9–10	2	18
Juniors.....	R. R. surveying (c)......	C.E. 7..	Prof. Melick............	111 Eng. Bldg....	8–9	3	24
Juniors.....	R. R. surveying (f)......	C.E. 7..	Prof. Melick, Mr. Kingman	....	1–5	4	10
Juniors.....	R. R. surveying (f)......	C.E. 7..	Prof. Melick, Mr. Kingman	....	1–5	4	9
Juniors.....	R. R. surveying (c)......	C.E. 7..	Prof. Melick............	111 Eng. Bldg....	3–4	3	19
Juniors.....	R. R. surveying (f)......	C.E. 7..	Prof. Melick, Mr. Kingman	....	8–12	4	24
Seniors.....	Thesis..................	C.E. 11.	Prof. Vedder............	106 Eng. Bldg....	1–5	20	21
Seniors.....	Contracts and Specif.....	C.E. 13.	Prof. Vedder............	111 Eng. Bldg....	10–11	3	25
Seniors.....	Contracts and Specif.....	C.E. 13.	Prof. Vedder............	111 Eng. Bldg....	11–12	3	25
Seniors.....	Astronomy (f)...........	C.E. 14.	Prof. Vedder, Mr. Powell.	111 Eng. Bldg....	....	2	28
Seniors.....	Astronomy (c)...........	C.E. 14.	Prof. Vedder............	111 Eng. Bldg....	11–12	2	28
Seniors.....	Road construction (f)....	C.E. 17.	Prof. Melick, Mr. Kingman	....	10–12	6	11
Seniors.....	Road construction (c)....	C.E. 17.	Mr. Kingman...........	120 Eng. Bldg....	11–12	2	11
Totals..	32 sections.............	....	....	....	....	126	681

The above table is to some extent incomplete and misleading. It does not give all instructors proper credit for work done, sometimes even directly in connection with the class work. For instance, during the fall term Mr. C. D. Curtiss was assigned to 16 hours per week of regular attendance in one of our laboratories where he prepared equipment and checked it out to students. Similar assignments were shared by Mr. Ockerblad and Mr. Powell in the spring term. Every teacher in the department has been held throughout the year for duties which do not show on the record of class work. A memorandum of every such assignment is carefully filed in the department.

The following text-books have been used in our classes during the year: Merriman and Jacoby's Roofs and Bridges, Vols. I, II, III; Hodgman's Land Surveying and Vedder's Notes on Surveying; Merriman's Treatise on Hydraulics; Johnson-Smith's Surveying; Church's Mechanics; Baker's Masonry Construction; Baker's Roads and Pavements; Turneaure & Russell's Public Water Supplies; Folwell's Sewerage; Hosmer's Astronomy; Tucker's Contracts in Engineering; Wilson's Topographic Surveying; Merriman's Mechanics of Materials; Allen's Railroad Curves and Earthwork.

The total expenditure by the department during the year for all purposes has been $1,683.08 of which $85.00 was turned in for special examinations, and $598.50 for laboratory fees and other departmental receipts.

Our inventory for 1912 shows the total value of equipment to be $21,615.50 as against $19,030.21 in 1910.

Respectfully submitted,

H. K. VEDDER,

Professor of Civil Engineering.

East Lansing, June 30, 1912.

REPORT OF THE DEPARTMENT OF PHYSICS AND ELECTRICAL ENGINEERING.

President J. L. Snyder:

Dear Sir—It is well perhaps to call attention occasionally to the fact that every student who spends two years at the college is required to take from two to three terms of physics and those who enter as subfreshmen take two or three terms of preparatory physics in addition, and, since physics is given in the freshmen and sophomore years after which time the classes diminish due to the dropping out of those who are unable to carry the course, we handle a great many students.

I have felt that some of the heads of the departments have not been entirely in sympathy with our methods of teaching physics, in that we are thought to spend too much time on principles and formulae and not enough time with laboratory practice of an elementary nature. During this past year four new men have been doing advanced work more particularly for the Experiment Station which necessitates a very complete knowledge of physics. These men have consulted freely with Prof.

Chapman and in every case their needs call for a very precise knowledge of the principles of physics. This has served to give Prof. Chapman an idea of just what the students here need in their course of physics and we hope that it will bear fruit in the immediate future. I believe that a good basic knowledge of the principles of physics is going to be considered very essential in the near future by instructors whether they have felt so in the past or not.

In the rearranging of courses it has been difficult to make the various terms' work quite even. However, the work in electrical engineering has been somewhat uneven and the two (being handled by the same department) have somewhat supplemented each other, due to the fact that Mr. Snow has been able to assist us in both departments. As it is, our spring term is still pretty heavy and as the number of students in the so-called agricultural class is increasing we are finding it difficult to handle all the work on the program with the facilities at hand. In the department we give instruction separately to the women, the engineers, and all of the rest of the students, which remainder includes the agricultural, veterinary and forestry students. I find in our conversation we are apt to class all of the latter as agricultural students because the first two years of their work has always been very much the same. With the increase in the number of agricultural, forestry and veterinary students that is taking place we shall soon have to deal with the matter of enlarged facilities. I think it would be very desirable for the strictly agricultural students (not including the forestry and veterinary students) to have another terms' work in physics.

We have been very fortunate this past year in having in the department as instructors only men who have been with us for one or more years which means a good deal for efficiency in handling the work. For the year 1912-1913 Mr. M. M. Cory will assist in the electrical engineering work in the place of Mr. Kelsall who has held that position for the last three years.

All of the members of the department have been efficient and especially helpful this year because of the interest taken in the work. Below is a list of the members of the department:

Assistant Professor, W. L. Lodge;
Assistant Professor, C. W. Chapman;
Instructors: W. E. Laycock G. A. Kelsall, O. L. Snow;
Clerk and Stenographer, one-fourth time, Miss Edna B. Spindler;
Caretaker, George Klotz.

Yours very truly,
A. R. SAWYER,
Professor of Physics and Electrical Engineering.

East Lansing, June 30, 1912.

REPORT OF THE DEPARTMENT OF DRAWING AND DESIGN.

President J. L. Snyder:

Dear Sir—I herewith beg leave to submit to you my annual report as head of the Department of Drawing and Design for the year ending June 30, 1912.

The department under the new schedule is offering 20 courses of which eleven are freehand and one a history course. Of these five are either electives or options. The three courses open as options as against music have proven very popular and the students have done good work, which seems to justify the experiment. There has been no falling off in attendance or interest.

I am planning the freehand courses to be as connected as possible and also progressive in the hope that the way may open up for the development of an industrial art course spoken of in my last report, when these would fall naturally into the general scheme. There is undoubtedly a strong feeling among the women in favor of such a course, and I feel sure that if available it would receive its fair share of students and prove popular and profitable.

Efforts are being directed all along the line toward co-ordinating and improving the courses; this work will probably not cease as improvement is always possible. We are gradually getting into the use of printed layouts in our mechanical courses, particularly in descriptive geometry. We believe it conserves the time of the student so he can concentrate attention to a greater degree upon the more important phases of the work.

The department equipment has been increased by a very much needed group of casts for the freehand classes, and the walls of the hallways have been hung with frames containing students' work; it is ultimately the purpose to include reproductions of works of art allied to the work done by students. It is also the aim of the department to broaden the students as much as possible consistent with the work they are scheduled to perform, and the teaching staff is being gradually trained to be leaders and guides not task masters, and I am pleased to say the enthusiasm and interest of the students in the various courses warrants the assertion that we are accomplishing our purpose. There is much left yet to be desired in the line of high standards of scholarship, but this can only come through a general stiffening in requirements all along the line and particularly in uniformity in rigid standards of scholarship after entrance, and less concern at the resultant thinning of the ranks of the students.

The department teaching has been done by the following staff mentioned in seniority of appointment: Victor T. Wilson, Chace Newman, Caroline L. Holt, Isabel Snelgrove, Max D. Farmer, J. L. Morse, Instructor in Mechanical Engineering; R. E. Bissell, Student Assistant.

Again I can report with satisfaction a fine esprit de corps of the teaching staff who have contributed so much to the success of the department work, and I am constrained to repeat again my hopes that a salary schedule may be decided upon so that deserving instructors may have something definite to look forward to as a reward for faithful

and satisfactory service. The present method of increase is very precarious from their standpoint.

The effect of the revision of the courses in the college on a 20 credit basis was felt again this year, temporarily lessening the teaching hours through fall and winter terms, accounting for the light schedules of some of the teachers in the table that follows. Next year the schedule will have become settled.

Following is a table which will show much data regarding attendance, teaching hours, etc.

Respectfully submitted,
VICTOR T. WILSON,
Professor of Drawing and Design.

East Lansing, June 30, 1912.

Drawing department.

Class.	Subject.	Instructor.	Fall term.		Winter term.		Spring term.	
			Hours per week.	No. of students.	Hours per week.	No. of students.	Hours per week.	No. of students.
Sub-freshman—Engineers	Drawing 1f	Miss Holt	4	23				
		Miss Snelgrove	4	27				
Sub-freshman-Engineers	Drawing 1g	Prof. Wilson			4	21		
		Miss Snelgrove			4	19		
Sub-freshman—Engineers	Drawing 1h	Prof. Wilson					4	19
		Mr. Farmer					4	16
Sub-freshman—Ag. & For.	Drawing 1a	Miss Holt					4	14
		Miss Snelgrove					4	12
Sub-freshman—H. E.	Drawing 1a	Miss Snelgrove					4	23
Freshman Engineers	Drawing 4ab	Prof. Wilson	6	25				
		Prof. Newman	6	28				
		Prof. Newman	6	27				
		Mr. Farmer	6	29				
Freshman Engineers	Drawing 4c	Prof. Newman			6	19		
		Prof. Newman			6	33		
		Mr. Farmer			6	26		
		Mr. Farmer			6	20		
Freshman—Engineers	Drawing 5ab	Prof. Wilson					3	28
		Prof. Newman					3	30
		Prof. Newman					6	30
		Prof. Newman					3	30
		Prof. Newman					6	30
		Mr. Farmer					3	26
		Mr. Bissell					6	27
		Mr. Farmer					6	26
Freshman—Ags. & For.	Drawing 3b	Prof. Wilson			4	18		
		Prof. Wilson			4	26		
		Prof. Newman			4	21		
		Miss Snelgrove			4	23		
		Miss Snelgrove			4	22		
		Miss Snelgrove			4	25		
		Miss Snelgrove			4	21		
		Mr. Farmer			4	21		
Freshman—H. E.	Drawing 1i	Miss Holt	4	119				
Freshman—H. E.	Drawing 1j	Prof. Wilson			4	18		
Freshman—H. E.	Drawing 1k	Miss Snelgrove					4	12
Sophomore—H. E.	Drawing 3a	Prof. Wilson					6	37
		Miss Snelgrove					6	26
Junior—Engineers	Drawing 7	Prof. Newman			6	16		
		Mr. Farmer			6	18		
Junior—Engineers	Drawing 6	Prof. Newman	6	22				
		Mr. Farmer	6	26				
Junior and Senior—Ags & For.	Drawing 3c	Mr. Farmer					10	19
Junior and Senior—H. E.	Drawing 1e	Miss Holt					6	2
		Miss Holt					6	8
Junior and Senior—H. E.	Drawing 1l	Miss Holt					5	2
Junior and Senior—H. E.	Drawing 2b	Miss Holt			5	27		
		Miss Holt			5	11		

REPORT OF THE DEAN OF THE DIVISION OF HOME ECONOMICS.

To the President, Dr. J. L. Snyder:

The report of the Dean of Home Economics for the year 1911-12 is herewith respectfully submitted.

The total enrollment for the year was 264, 10 of whom only were specials. Thirty-one were registered as seniors, one of whom received her degree at the end of the fall term as of the class of 1911. The remaining 30 made the largest class ever graduated from the division.

Again the Woman's Building was crowded to the utmost. The Terrace, under the efficient supervision of Mrs. Peppard, the resident teacher, accommodated 35 young women during the first term and only a few less for the remainder of the year. Two houses were secured near the Building on Grand River Avenue, in each of which 12 young women were placed and which proved throughout the year very convenient for the extra students. Our thanks are due to Mr. and Mrs. H. R. Bowles and to Mr. and Mrs. C. L. Coffeen for their interested co-operation in the care of these students in their homes. This increased number with our resident teachers taxed the capacity of our dining room. Our House Director, Mrs. H. B. Crawford, was able to meet the emergency, however, and a high standard of excellence was maintained in this department. It is clearly evident that we must have added facilities for the proper care of the young women who are ready to enroll with us.

The officers and teaching force and the average number of lecture and laboratory hours for each was as follows:

Miss Agnes, Hunt, B. S., Professor of Domestic Science.	17
Miss Grace E. Stevens, A. B., Instructor in Domestic Science and Art	20⅓
Miss Hazel Berg, A. B., B. S., Instructor in charge of Domestic Art	19⅓
Mrs. L. L. Peppard, Instructor in Domestic Art	21
Miss Louise Freyhofer, B. S., Director of Music	21 (2 terms)
Miss Irma Himelberger, Instructor in Music	23 (1 term)
Miss Grace L. Scott, Instructor in Music	22
Miss Delia Bemis, Instructor in Music	7⅓
Miss Edith W. Casho, Instructor in Physical Training	17
Mrs. Harriet B. Crawford, House Director.	

The valued work done by the two last named, in the care of the sick and inspection of rooms, is worthy of record. I wish here to express appreciation of the efficiency and sympathetic co-operation of all our workers, which is the keynote to success both in our family life and in the class room.

The new course of study, with its adjustments now secured, is proving its value. We are glad to note the higher grade of work as evidenced by fewer failures and conditions and by a general spirit of

scholarly interest. An honor society, Omicron Nu, organized in the spring term, has for its purpose the promotion of home economics and scholarship among its students. The 11 senior women who were its charter members had maintained high scholarship during their college course and given promise of future achievement. The faculty of the Home Economics division, to whom the organization of Omicron Nu is due, feel gratified by the attitude of the student body toward this new honor society.

The new and quite complete equipment of the Domestic Science laboratory has proven very satisfactory. Special student investigations on corn meals, on winter and spring wheat flours, on shrinkage in pickles, etc., have given good results and will be carried further in the future. The report made by Misses Elizabeth M. Palm and Alice E. Jeffery of an investigation conducted by them last year on lunch baskets was published in the Home Economics Journal for June, 1912.

Some special apparatus in the gymnasium makes possible more work for particular needs of individual students. The music department has, as usual, aided in various programs, has organized a Girls' Glee Club and has given several recitals, one of which was the best for years past.

The textiles course gave opportunity for testing fabrics and their adulterations and for microscopic work on the textile fibers. An interesting problem was the cost estimate of a young woman's wardrobe according to different standards. Two classes from the East Lansing public schools came once a week to the laboratory for instruction in sewing, given by the senior girls under the direction of Mrs. Peppard. An electric motor, a skirt marker and other smaller articles have been added to the equipment in domestic art. An interesting exhibit of the dressmaking courses, showing the work in costume design, was made two or three times during the year, on the occasions of the Women's Congress of the Round-up, the Michigan Home Economics Association, the Women's Press Club, etc.

In addition to these meetings, the committee of School Patrons of the National Educational Association, of which the Dean of Home Economics is member at large for Michigan, held its annual meeting in the Women's Building. We had also the pleasure of entertaining at luncheon in May a company of faculty ladies from Ann Arbor, including Mrs. Hutchins and Dean Jordan, who were interested in the possibility of introducing Home Economics at the University of Michigan.

Some of the speakers from abroad who have been guests of the department during the year are Mrs. C. E. Faulke of Ohio, Dr. Mary Louise Hinsdale of Ann Arbor, Mrs. Forbes Robertson Hale of New York, Mrs. Jennie C. Law Hardy of Tecumseh, Miss Mary Snow of Chicago, and Miss Grace L. Coppack of China.

We wish to express appreciation for courtesies to the classes in Household Art and Institution Management, extended by Mesdames O. M. and O. F. Barnes, Miss Parker, and Mrs. James M. Turner, also to Dr. Kellogg and Miss Cooper of the Battle Creek Sanitarium for their generous hospitality to the senior class on its inspection trip.

The Students' Aid Fund, inaugurated last year by the College

Women's Club, has been increased by the same ladies and is now available for worthy students of the upper classes.

The Idlers planned a Christmas gift to the building, which was delayed, however, until late in the year,—a handsome carbon photograph, beautifully framed, of Inness' "Peace and Plenty." This is the first gift of the sort and is highly appreciated by all.

In closing permit me to call attention to some of the needs of the department. An elevator in the Woman's Building has become a necessity. Better equipment of the Terrace with a supply of hot water, so long as it must be used for rooming purposes, is necessary. A new residence hall or the wing, as originally planned for the Building, is seriously needed. Both of these could be filled within a year, so great is the demand for home economics training.

Respectfully submitted,

MAUDE GILCHRIST,

Dean of the Division of Home Economics.

East Lansing, June 30, 1912.

REPORT OF THE DEAN OF THE VETERINARY DIVISION.

President J. L. Snyder:

Dear Sir—I herewith submit the annual report for the Veterinary division.

Gratifying progress has marked the further organization of the division as one of the co-ordinate branches of instruction at this institution, and in offering this optimistic decision, one cannot overlook the greater appreciation of the character of the work contemplated, as is evidenced through the genial co-operation of other departments.

The work of organization has so materially advanced that this school of instruction is now justified in claiming a place in the front rank of veterinary institutions. As a prerequisite, we require graduation from an accredited high school, and the vocational course beginning next September will cover a period of four collegiate years, the work being so arranged and graded as to furnish the student with the essentials that should render him competent to compete with graduates from any institution of allied character in America.

The instruction that may be termed purely professional in character has been altered in designation, rearranged, and classified (a change made possible through the addition to the instructing force of Dr. John S. McDaniel, B. S., D. V. S., graduate of the University of Missouri, and also of the Kansas City Veterinary College), thus permitting the creation of five departments directly under the supervision of the Veterinary division, as required of competent veterinary institutions of America. They are as follows: Medicine, Pharmacology, Anatomy, Pathology and Surgery; the subjects embraced within these several departments have been redistributed throughout the three terms of the fiscal year, with a view toward better equalization of the teaching hours, and moreover, with the addition to the teaching force recently author-

ized, it is anticipated that the character of the instruction will be very materially enhanced by permitting a wider distribution of the burden of work as outlined in the Veterinary course. As now arranged, after eliminating such other subjects as are essential for veterinary students, but which are given in other departments, that is, physiology, zoology, animal husbandry, dairying, chemistry, botany, etc., the distribution of professional work is as follows:

DEPARTMENT OF MEDICINE.

Medicine, Theory and Practice	Junior and Senior
Clinic Medicine	Junior
Clinical Technique	Sophomore
Veterinary Science	Freshman
Opthalmology	Senior
Veterinary Science, short course first year.	

DEPARTMENT OF PHARMACOLOGY.

Materia Medica	Sophomore
Pharmacy	Sophomore
Toxicology	Junior
Therapeutics	Senior
Veterinary Science, Agricultural	Junior and Senior
Veterinary Science, short course, second year.	

DEPARTMENT OF BACTERIOLOGY AND PATHOLOGY.

Bacteriology	Sophomore
General Pathology	Junior
Morphologic Bacteriology	Junior
Bacteriology and Pathology	Senior
Parasites and Parasitic Diseases	Senior
Post Mortem Examination	Senior
Meat Hygiene	Senior
Infectious Diseases	Senior

DEPARTMENT OF ANATOMY.

Zootechnics	Freshman
Anatomy, Gross	Sophomore and Junior
Histology	Sophomore
Embryology	Sophomore

DEPARTMENT OF SURGERY.

Animal Dentistry	Sophomore
Lameness	Junior
General Surgery	Junior
Shoeing and Balancing	Junior
Surgical Clinic	Senior
Soundness and Examination	Senior
Special Surgery	Senior
Obstetrics	Senior

This distribution of work ranges from a minimum in one instance, and in one term only, of 13 weekly hours to a maximum of 30 weekly hours for a single individual, irrespective of the volume of unscheduled clinic work.

I took occasion in a letter addressed to you under date of December 12 last, to call attention to our dire need of better building equipment for anatomy, surgery and hospital facilities. This petition has been given due consideration by the Board, and through their authorization of plans, specifications, and bids for such a building, we are anticipating that the character of the work will be further elevated and opportunities for clinic instruction materially facilitated. In preparing plans for this building the object has been to secure a plain, useful structure that will conserve the best purposes with the room offered, and be suitable for modern surgery and instruction in gross, histologic and embryologic anatomy, as well as afford adequate quarters for the care of clinical or surgery cases that we hope to house for student observation during treatment.

At the opening of the next college year the division will be under full operation, and for the first time prepared to offer work of the entire course. Consequently at the close of 1912-1913 we will have passed beyond the formulative period. The past year has witnessed progress in the greater efficiency of the courses offered in each department, and without going into lengthy detail, it is competent to state in connection with the several phases of anatomy, that is, gross anatomy, histology and embryology, that much of the work has been of a laboratory nature, necessitating a large amount of material, the preparation of which has involved no little time and expense; considerable material, however, has been collected and it is anticipated by the instructor in charge that this will be classified and so arranged during this summer vacation that the value of the course to the student will be very materially increased.

In the clinical work, which is included through a combination of the departments of medicine and surgery, a large share of actual training has been afforded each student, and this of a nature to very materially broaden preparation for actual practice. The available clinic of the past year, exceeding our most sanguine anticipation, was both varied and good, but we were absolutely unprovided with facilities for the adequate shelter and care of the sick or surgical cases; the training that we have attempted to instill into the student mind we fear lacks effectiveness, and without proper building facilities, there is eminent danger of public condemnation rather than appreciation.

As reported a year ago, radical changes were made in the instruction offered as an elective veterinary science course for senior and junior agricultural students. That these changes, as outlined in my last report, have seemed to more nearly meet the requirements would appear evident in the increase of fully 40 per cent over the number of students enrolled a year ago. Besides the duties directly pertaining to the giving of adequate instruction for the several classes of students scheduled, which includes regular freshmen, junior and senior agricultural students, two classes in short course agriculture, and short course in dairying also sophomore and junior veterinary students, the division has been able to furnish speakers for a number of dairy and agricultural

gatherings, as well as send a representative to the annual conference of the New York State Veterinarians, held under the auspices of the New York State Veterinary College, Cornell University. We have also entertained in a two days' convention the Michigan State Veterinary Medical Association, thereby helping to more intimately unite the interests that are common to this department of instruction and the practicing veterinarians of Michigan; in this connection it may be mentioned that an invitation has been extended for the same association to meet with us for its next annual convention, and likewise that we are hoping to find it convenient to arrange for a winter's short course in veterinary science subjects, to be open to graduated practitioners of the state.

It is our aim to train students as thoroughly high classed practitioners, and thus meet the increasing demand to render help to live stock owners of this state, and realizing the value of a broad and liberal preliminary training, it is our desire to make the course attractive to graduates of land-grant agricultural colleges. With this thought uppermost, the following resolution was recently presented to the faculty of the college and received their endorsement:

"Any graduate of an accredited agricultural college which includes in its curriculum not less than ten credits of veterinary science under a regularly graduated veterinarian, will be admitted to the junior year of the veterinary course, but will be required, prior to the spring term of the senior year, to pass off or provide proper substitutions for all freshman and sophomore technical subjects.

"To pass on these matters, a standing committee of three, with power, shall be appointed by the president.

"Provided, however, that the head of any department offering a subject in the junior or senior year may specify the prerequisite qualifications for that subject."

We fully believe that many students will eventually avail themselves of the opportunity that is here offered, and that the results will be influential toward manifest returns in the protection of the live stock of Michigan against disease.

Respectfully submitted,

RICHARD P. LYMAN,

Dean of Veterinary Division.

East Lansing June 30, 1912.

REPORT OF THE DEPARTMENT OF BACTERIOLOGY AND HYGIENE.

To President J. L. Snyder:

In submitting my report for the past school year, it is unnecessary to repeat what has been stated in previous reports. I can confine my comments to a few features which have developed during the course of the year.

In the instruction of the 200, and over, sophomores, we have been able for the first time to employ a text-book pertinent to agricultural work. It has been a great advantage in many ways, because it has been our experience that the sophomores had very little opportunity to develop their powers of note-taking when class work is limited to lectures. Accordingly, in addition to the subject matter in the past, it has been part of the course to accustom students to lecture work. On the other hand, lecture work offers many advantages not secured by the exclusive use of a text-book. The emphasis of a course can be placed in lecture work when it cannot be furnished as effectively in text-book work. We have, therefore, endeavored to obtain as far as possible some of the advantages offered by each system through a combination. We also adopted the well-known "blue book" system. We introduced this system with some degree of hesitancy, not knowing how valuable it would be in this institution. Our course, as you know, consisted of two hours a week. Fifteen minutes at the beginning of one of these periods was devoted to two or three questions, the answers to which were written by the students in the "blue books." Before this occurred the following week, the answers were looked over and the grades marked in red ink. This enabled the student to follow his work very carefully and to know just what he was doing. It also enabled us to carry on our class quizzes more effectively. After the students had followed this plan for one term, they were asked to give their verdict. It was unanimously in favor of the plan.

The laboratory work under Dr. Rahn, consisting of Bacteriology II, III and IV, has given the best of satisfaction. This year marks a degree of attainment in this respect not before reached. I believe this to be due largely to the high character of work offered and the precision of the exercises. Any student completing the laboratory courses satisfactorily under the direction of Dr. Rahn has acquired not only a workable knowledge of bacteriology but an intelligent understanding which will enable him to utilize it to good advantage in practice.

The sanitary and pathological courses, offered to the agricultural and veterinary students, have been conducted by Dr. Ward Giltner. Dr. Giltner's work has appealed strongly to the students. He finds that too little time is allowed to cover the work that should be given to students. Dr. Giltner has also conducted a class of short course men. The work furnished these men was largely of a sanitary nature.

Mr. C. W. Brown had charge of the short courses in dairying, comprising creamery work and cheese work. The results secured in carry-

ing on this work indicate that Mr. Brown has been very effective and has reached these men whose minds are exclusively upon the manufacture of dairy products. Mr. Brown has also been associated with Prof. A. C. Anderson in conducting a course upon market milk during the past spring term. This course has consumed about three hours a day of his time, but has been fruitful and suggestive.

The courses consisting of the hygiene of foods and sanitary science for young ladies have been under the direct charge of Miss Z. Northrup. Miss Northrup has shown her ability in providing young ladies with such basic facts as must be of great utility to them in their domestic science work. These courses have proved to be very useful.

In closing this report, I wish to express my appreciation of the loyal, faithful and intelligent support of the collaborators in the department who have taken part in the work of instruction.

Very respectfully,
CHARLES E. MARSHALL,
Professor of Bacteriology and Hygiene.

East Lansing, June 30, 1912.

REPORT OF THE DEPARTMENT OF BOTANY.

To the President:

Dear Sir—I beg leave to submit herewith my annual report for the Department of Botany for the year ending June 30, 1912.

The botanical staff for the past year has been, with two exceptions, the same as the preceding year. Dr. William H. Brown, Research Assistant in Plant Physiology, resigned to take effect September 1, 1911, to accept a position in the Bureau of Science at Manila, P. I. His position was filled by the appointment of Dr. Rufus P. Hibbard, previously Botanist of the Mississippi Agricultural Experiment Station. Mr. J. C. Th. Uphof was appointed to take charge of the Botanical Garden and Herbarium.

The botanical staff at the close of the year, was accordingly, as follows:

Ernst A. Bessey, Professor of Botany; Dr. Richard deZeeuw, Assistant Professor; Dr. Ruth F. Allen; Miss Rose M. Taylor and Miss Bertha E. Thompson, Instructors. Mr. J. C. Th. Uphof, in charge of the Botanical Garden and Herbarium; Dr. Rufus P. Hibbard, Research Assistant in Plant Physiology, and Prof. George H. Coons, Research Assistant in Plant Pathology. The last two devote only one-fourth of their time to teaching in the college, the remaining three-fourths being devoted to research work in their respective subjects for the Experiment Station.

The number of students enrolled in the department during the past year has been as follows: Fall term, 415, of whom 331 were taking required subjects and 84 elective subjects. Winter term, 483, with 444 required and 34 elective. Spring term, 290, with 234 required and 56

elective. In addition, there were 41 enrolled for the short course lectures on Plant Diseases.

During the past year, the large collection of logs and tree sections stored in the hallway of the old part of the building and concerning which I reported last year, has been turned over to the Forestry department so that this danger from fire has been removed. This has permitted us to use the large basement hallway for storage of specimens for class use and to fit up part of the northeast basement room as a seed laboratory and part as a store room for suppplies and tool shop.

In my last report, I mentioned the very crowded condition of the Herbarium and called attention to the advisability of extending it. I would recommend that a competent person be assigned to investigate the possibility of providing the room adjacent to the Herbarium with steel and cement fireproof ceiling similar to that in the Herbarium, since I do not wish to risk placing a valuable collection in a room that is not fairly fireproof.

With the appointment of Mr. Uphof to take charge of the Botanical Garden and Herbarium, we have gained a valuable aid. The Botanical Garden is now, in spite of the damage done by the flood this spring, in better condition than for years. The plants, many of which in the course of the past few years, had become wrongly labeled, are being correctly identified. Mr. Uphof has collected seeds of all the plants of which we have correct names and we hope to exchange seeds with other Botanical Gardens this fall. This spring, we obtained seeds and plants of several hundred species representing some of the most important families of the temperate region. The grass garden was, futhermore, considerably extended and the grasses reset since they had become badly mixed and crowded. An attempt was made to extend the weed garden but, owing to the poorness of the soil, without the best success. However, this will be remedied this fall. Mr. Uphof has also collected many plants native to this vicinity, many of which had formerly been in the Botanical Garden but which, in the past few years, had died out. These have been set out. We expect to continue to add Michigan plants to the garden as fast as they can be cared for so that in fact as well as in theory, we may have a representative collection of Michigan plants. Mr. Uphof has also been intrusted with the rearrangement of the plants in the Herbarium, arranging them according to the more modern botanical system, as well as separating the Michigan plants from the others.

By action of the Advisory Board of the Geological Survey of Michigan, all plant collections made under the direction of this survey, will be deposited, hereafter, in the Herbarium of the Botanical department of this college, subject to recall should it be deemed necessary. Already one such collection has been received and will soon be available for use. Others are expected next winter as the result of the activities of collectors this summer.

The Herbarium has continued to receive the standard sets of certain fungi and algae in addition to material obtained by collection in this vicinity. I plan to spend a small amount of money in having collections made within this state this summer, collecting both specimens for the Herbarium and live plants for the Botanical Garden.

There have been added to the equipment of the laboratory a number

of pieces of apparatus, among them a centrifugal apparatus for work in plant physiology; a drying oven, steam sterilizer, still, mimeograph, etc. Mimeographed laboratory directions are now being furnished to the students so that it is not necessary to use the blackboard for this purpose.

I wish to call attention to the fact that the photographic dark room is entirely too small to be convenient or even give the best results, while it is very uncomfortable on account of its size. At a comparatively small expense, this can be more than doubled in size without interfering with the other rooms. It is hoped that this may be permitted to be done.

In connection with the class on weeds and weed seeds, this year, I am planning to have a number of sets of 100 more important seeds put up to be used in particular by the students taking this course and to be supplied at about cost, to agricultural high schools. Professor Coons, the Plant Pathologist, is also planning to prepare sets illustrating the more typical plant diseases for similar distribution among agricultural high schools. It is thought that these two sets will both be of exceptional value.

In view of the fact that it will only be a year or two before the natural growth of the college will require the fitting up of an additional laboratory room for freshman and sophomore botany and also in consideration of the very crowded condition of the room now occupied by the Botanical division of the Experiment Station which has had to overflow into the hall, basement and greenhouse, I feel that it will be advisable to have some competent architect look into the question of extending the walls upward so that the roof in both parts of the building over the attic may be flat as in the Agricultural and Woman's Buildings instead of as it now is. If this is done, the available space in the Botanical Building will be increased by fully 33 per cent. I would then place the Botanical division of the Experiment Station on the top floor of the new part of the building, giving them the whole floor. This would make the room now occupied by them available for class work, for which purpose it is even now much needed. It would also make the attic of the old building available for two laboratories. The one laboratory that is now there cannot be used to advantage on account of the small windows set in deep recesses. The feasibility of this should be determined as soon as possible and plans made so that the matter may be undertaken perhaps a year from now.

Respectfully submitted,

ERNST A. BESSEY,

Professor of Botany.

East Lansing, June 30, 1912.

REPORT OF THE DEPARTMENT OF CHEMISTRY.

Mr. J. L. Snyder, President Michigan Agricultural College:

Dear Sir—The following schedule shows the courses given and the number of students in each course, together with the class to which the students belong,—representing therefore the work of the entire force of the Chemical department for the year 1911-1912:

Fall Term, 1912.	No. students.	Total.
General Chemistry: Chemistry (1).		
Agricultural freshmen	211	
Engineering freshmen	130	
Women freshmen	95	
Women sophomores	59	495
Organic Chemistry: Chemistry (3).		
Agricultural, Forestry and Veterinary freshmen	100	100
Quantitative Analysis: Chemistry (7).		
Agricultural juniors and seniors	50	
Women	5	55
Total students enrolled in the Chemistry department during Fall Term	....	650

Winter Term, 1912.	No. students.	Total.
Qualitative Analysis: Chemistry (2). Agricultural freshmen	195	
Qualitative Analysis: Chemistry (9). Women freshmen and sophomores	126	
Qualitative Analysis: Chemistry (12). Engineering freshmen	116	
Agricultural Chemistry: Chemistry (4). Agricultural and Forestry juniors and seniors	38	
Dairy Chemistry: Chemistry (5). Agricultural seniors	13	
Organic Preparations: Chemistry (8). Agricultural, Forestry and Homes Ecomonics jrs. and srs.	12	
Forestry Chemistry: Chemistry (6). Forestry seniors	13	
Engineering: Chemistry (14). Engineering seniors	55	
Total students enrolled in the Chemistry department during Winter Term	....	568

Spring Term, 1912.	No. students.	Total.
Organic Chemistry: Chemistry (3). Agricultural freshmen	184	
Metallurgy: Chemistry (13). Engineering freshmen	106	
Agricultural and Sanitary Analysis: Chemistry (18). Agricultural seniors	9	
Chemistry of Food and Nutrition: Chemistry (11). Home Economics Course, Women jrs. and srs.	10	
Total students enrolled in the Chemical department during Spring Term	....	309

Animal Nutrition: Chemistry (16).
(Not given on account of accident to Professor Kedzie, April 6, 1912.)

This year we have entered upon the plan of giving all the required chemistry in the Agricultural and Forestry courses in the freshman year, making a continuous three terms work in chemistry for men in these courses. I, however, regard this change, desired by the faculty, as more or less of an experiment and question very much in my own mind whether chemistry should be placed so early in the course.

Almost exactly 40 years from the time of the laying of the foundation of the original Chemical Building at M. A. C. the erection of the new addition authorized by the Board in 1910 was begun, and very fortunately was completed in time to be occupied at the opening of the college year 1911-1912.

As this new portion of the laboratory has some features which are of interest to former students and graduates as well as those persons who make a study of the construction of chemical laboratories, I have had prepared plans of the new addition as well as the entire building as it now exists. Figure 1 shows the south front of the Chemical Building, Figure 2 shows the north front of the Chemical Building and Figures 3 and 4 show the general plan of the main floor and lower floors of the building. As the amount of money provided limited us to the erection of a building which provides space for a new lecture room and one large additional laboratory, whatever else was put into the building came in as a secondary consideration.

The new lecture room is somewhat unique in construction owing to the fact that the windows are placed at such an elevation that it is impossible for the student's attention to be attracted by what occurs outside, yet by means of a skylight over the lecture table the room is flooded with light. (Figure 5.) The illustration gives an incomplete idea of the arrangement of the seats and lighting. The seats (250 in number) are placed on a cement raised platform going back ten steps. Fortunately on account of the shape of the room and the arrangement of the seats, each student has a full and free view of the lecture table. The space beneath this elevated seating stage has been utilized for two very pleasant and convenient laboratory rooms. Beneath the new lecture room on the lower floor is the new organic laboratory, which provides laboratory space for 180 separate students and working space for 144 at a maximum. By sectioning the class we usually are not obliged to accommodate more than 60 at any one time in this room. This laboratory is lighted by 19 windows so placed that light comes from every side. Figure 6 gives us an idea of the laboratory tables and light, as the center of the picture represents the center of the room.

By going below the ground line in construction nearly one-third of the height of the room is below the ground level. This tends to keep the temperature of the room, even in the warmest or coldest weather, fairly stationary. There are no ventilating hoods in this laboratory to cut off light. In place of these are 13 flues built in the wall and continued through the roof. These terminate at the proper working height above some slate slabs and give the advantages of draft hoods at 13 different points in the room.

Old. Fig. 1. New.

New Fig. 2 Old.

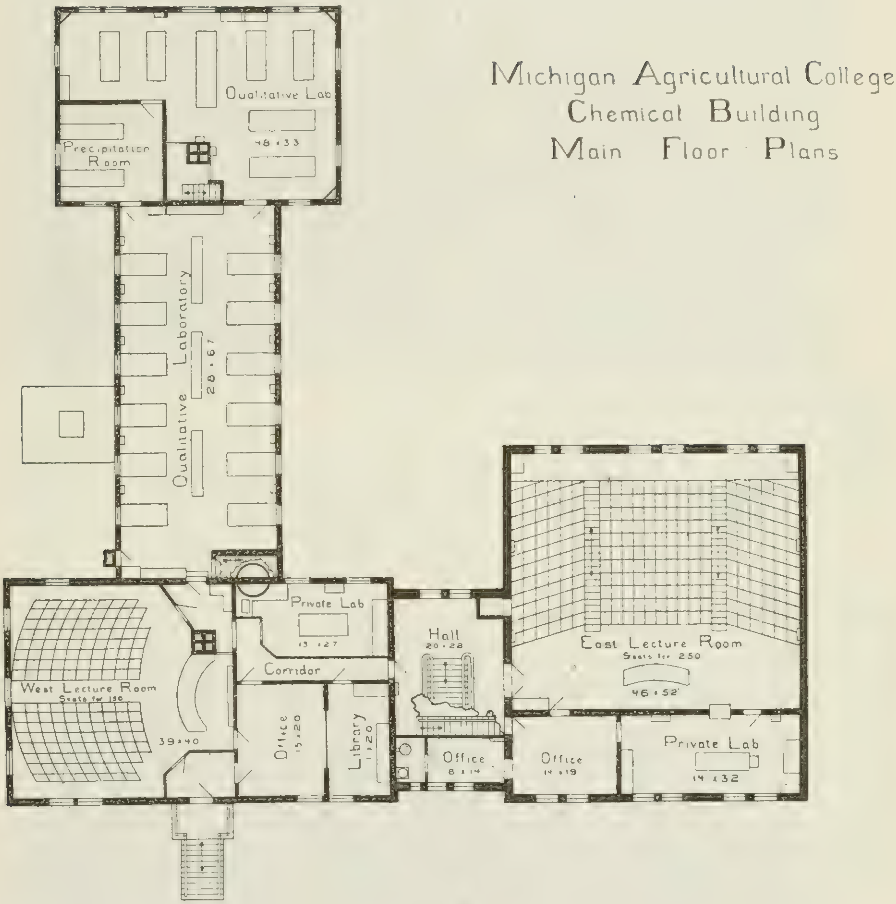

Michigan Agricultural College
Chemical Building
Main Floor Plans
Qualitative Lab
48 x 33
Precipitation Room
Qualitative Laboratory
28 x 67
Private Lab
13 x 27
Corridor
West Lecture Room
Seats for 130
39 x 40
Office
15 x 20
Library
Hall
20 x 22
Office
8 x 14
Office
14 x 19
East Lecture Room
Seats for 250
46 x 52
Private Lab
14 x 32

Fig. 3.

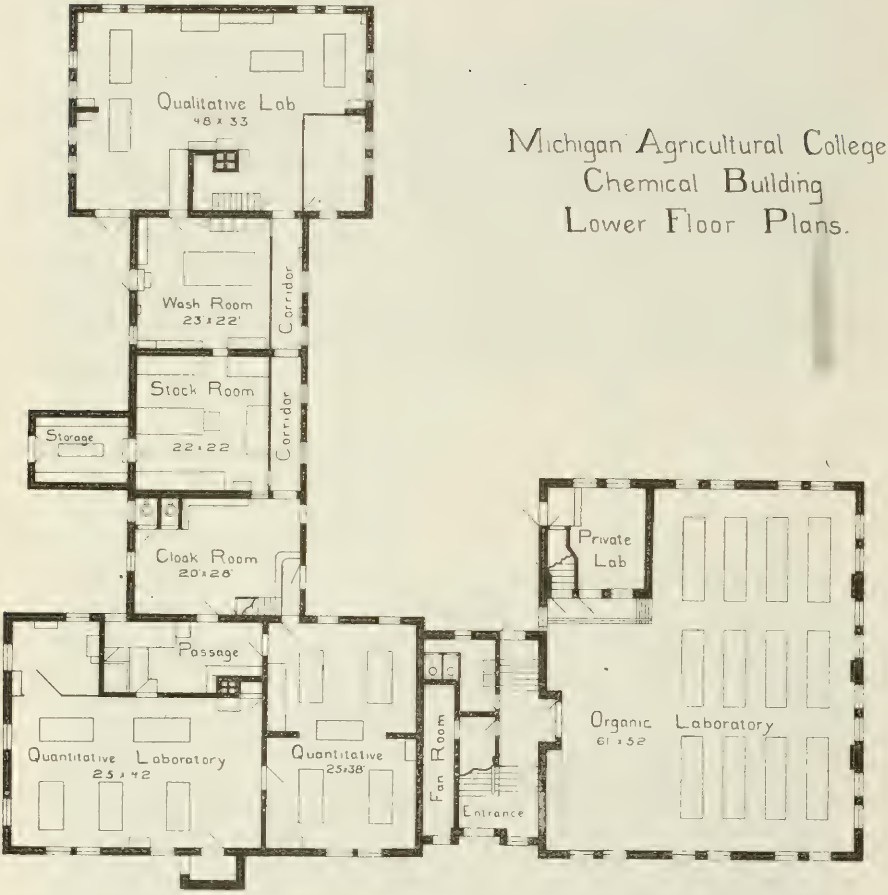

Michigan Agricultural College.
Chemical Building
Lower Floor Plans.
Qualitative Lab
48 x 33
Wash Room
23 x 22'
Corridor
Stock Room
22 x 22
Corridor
Storage
Cloak Room
20 x 28
Passage
Quantitative Laboratory
25 x 42
Quantitative
25 x 38
Fan Room
Entrance
Private Lab
Organic Laboratory
61 x 52

Fig. 4.

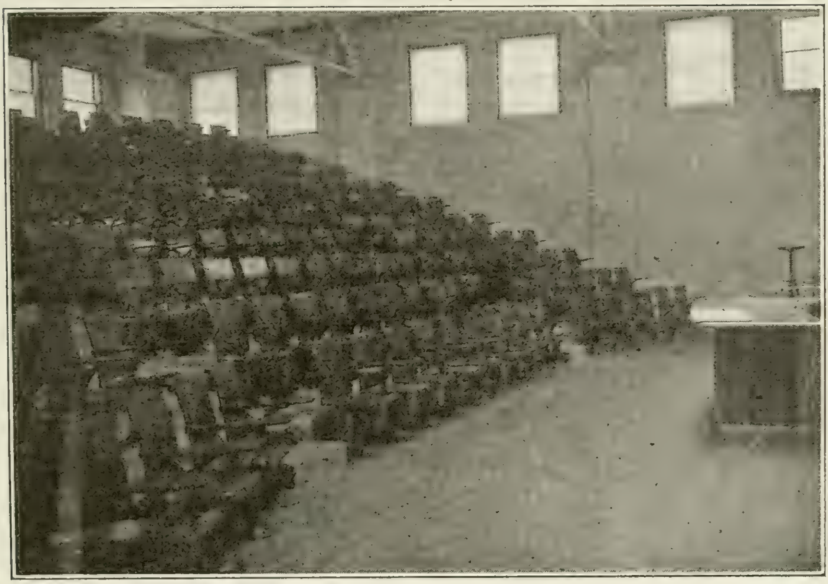


Fig. 5.

Fig. 6.

In the fan room, shown on the plan, is placed a powerful fan which furnishes air to this laboratory as well as all the other rooms in this part of the building. Consequently there is always a strong draft through our 13 flues providing thus for the escape of steam from evaporations and any noxious vapors produced in various experiments.

Heretofore we have been handicapped by having no proper study for the instructors, so by a little economizing of space on the floor immediately above the office and private laboratory in the new addition, two small private laboratories connected with a study room have been constructed for the instructors.

The space in the older portion of the building which was formerly used as an office for the head of the department and his assistants, has been utilized by putting in a partition dividing the office into a library and office for the assistant professors. The library is a room 11x20 feet which now holds the chemical laboratory library and which is in constant use by both the instructional force and the students.

In that portion of the building which was originally occupied by the Physical department (at the extreme north end) we have now established an additional qualitative laboratory, 48x32 feet, providing desk room for 32 students. The room below, which was formerly the Physical laboratory, now furnishes desk room for 16 students in qualitative analysis and provides also for the work of preparing reagents.

The original laboratory provided lecture room accommodations for 80 students and laboratory space sufficient for 48 students to work at one time. With our new addition our lecture room space provides for 400 students to attend lectures at the same period and laboratory space sufficient for 286 different students to engage in laboratory work at the same time.

BEET SUGAR SCHOOL.

Coincident with the establishment of beet sugar factories in Michigan in 1899 a technical course was given at this college aiming to train men in the chemistry of sugar-house control. After conducting such schools for several years in succession it was found that the demand for men so trained was not sufficient to make the further offering of such a course necessary. Consequently there has been no special course in beet sugar technology offered at M. A. C. for several years past. In the meantime, men who had engaged in the industry in various capacities found that there was but little opportunity while busy with the work of the campaign to obtain a thorough understanding of the scientific foundation upon which the successful operation of the factory depended. This matter was brought to my attention and the request made by Mr. W. H. Wallace of the Michigan Sugar Company that a short course for the benefit of sugar-house employes should be inaugurated. This was done and the course opened on March 4, 1912, continuing for exactly four weeks. The work of instruction was given entirely by Superintendent W. H. Hoodless of Croswell in conjunction with Assistant Superintendent M. R. Allen of Alma. Forty-six men from 12 different factories in Michigan attended the course. The technical features of factory management as well as careful study of the details of the various processes were thoroughly discussed by Mr. Hoodless and others at the morning session, the afternoons being mainly

devoted to drill in laboratory work connected with factory control. Among those taking the course were superintendents, factory managers, chemists, sugar boilers, foremen, etc. I believe that the work done in the course will prove to be of decided benefit to those men in carrying out the next campaign's work.

At the close of last year Assistant Professor Reed, who has been a most valuable aid in instruction and investigation, severed his connection with the department to take a position with the Detroit Testing Laboratory as research chemist, becoming associated with Mr. Floyd W. Robison, former State Analyst. Mr. Reed during the nine years he was connected with the department did most admirable work, and was highly regarded by his co-workers of the department as well as the students with whom he became associated.

The personnel of the department for the past year has been:

A. J. Clark, Assistant Professor.

R. C. Huston, Assistant Professor.

J. C. Bock, Instructor.

B. E. Hartsuch, Instructor.

F. W. Bentzen, Instructor.

J. R. Mitchell, Instructor.

H. H. Morris, Instructor.

W. G. Crawford, Instructor, (special for the winter and spring terms).

F. C. Kaden, Assistant (of the class of 1912).

G. W. Churchill, Caretaker.

E. A. Goodhue, Clerk.

I wish to acknowledge the co-operation of every one of the above named persons whose earnest endeavor has been to further the work of the department.

Respectfully submitted,

FRANK S. KEDZIE,

Professor of Chemistry.

East Lansing, June 30, 1912.

REPORT OF THE DEPARTMENT OF ENGLISH AND MODERN LANGUAGES.

President J. L. Snyder:

Dear Sir—In the Department of English and Modern Languages the enrollment of students during the college year 1911-1912 was as follows:

	English.	German.	French.	Total.
Fall term	822	82	73	977
Winter term	817	62	52	931
Spring term	728	50	43	821

The average enrollment per term was 909 as compared with 1,543 during the year 1910-1911. The decrease in the number enrolled has been due to two factors: First, the change in the course of study for agricultural, forestry and home economics students, omitted a number

of subjects formerly given in English; second, certain courses given by the department as one or two hour courses were combined, making three or five hour courses. In hours of teaching little less work was done by the department than during the preceding year.

The average cost of instruction per student in the department during the year has been $14.13, or $6.58 more than during the year 1910-1911. The head of the department, one assistant professor, and ten instructors have done the work of the department during the year. Mr. Milton Simpson and Mr. W. S. Bittner took the places made vacant a year ago by the resignations of Messrs. Von Tungein and Pyke. The former of the two instructors who left practically doubled his salary by going elsewhere; the latter went to Harvard to continue his graduate work, with the intention of accepting a position offered him in one of the Chinese universities. The average salary paid to the instructors during the year has been $915; the average salary during the year 1910-1911 was $825.

The work of the department has been made more practical and more clearly related to the day's work than ever before. All freshman men have been given a very thorough course in business letter writing. This has interested them more than any other work done with the freshmen since I have been here. The engineering freshmen have also given careful study to a volume of engineering addresses recently put forth for use in engineering colleges by Waddell and Harrington, a firm of contracting engineers in Kansas City. The book has furnished an admirable number of selections for the practical study of exposition, and at the same time has given the young engineers many practical suggestions and much helpful information, as the addresses studied were all delivered by engineers. The courses in public speaking have aimed more definitely than before at giving the young men power to prepare and to deliver effective extemporaneous addresses. Their practice has been along the line of addresses suitable to the work which they will undertake upon the completion of their college course. The aim in the classes of literature, more than before, has been to give students a power to appreciate the good things in literature, in order that they may read wisely and helpfully after their school years are finished. As I review the work of the year, I feel that it has come nearer to the ideal which I set when I undertook the work of the department than has been the case during any other year.

The course in agricultural journalism has been the most successful the department has yet presented. Almost every student in the class has sold at good prices to agricultural papers some of the work prepared for the class room. In several instances papers of the highest rank in the country have accepted and paid liberally for this work. For the first time students were required to present in typewriting all work prepared for this class. To enable students to do this two rebuilt typewriters were purchased by the department during the year. Every student felt that this feature of the work was exceptionally helpful, and they all recommended that it be continued. Further, they felt that to require all freshmen to hand in at least a part of their theme work in typewriting would be a distinct advantage to the student body. I concur with this belief myself and recommend that additional rebuilt

typewriters be secured and that in the future all freshmen be required to do at least part of their written work in this way. For students to supply themselves with a typewriter when they enter college would be wise. Notebook work done thus will have a value that otherwise it cannot have. The typewriter makes for accuracy as the pen someway fails entirely to do. As it is possible to secure rebuilt typewriters that are entirely satisfactory for as low a price as $12 or $15, there is no satisfactory reason why every freshman should not be urged to supply himself with a machine.

As in English, so in the modern languages, the thought of the practical value of the work has been ever kept to the front. Books dealing with German life and customs, accompanied by careful map study and current magazine reading, have been prominent in the work in German, and similar work has been done in French. Mr. Fischer, a very valuable instructor in German, has been recommended by the Carnegie Foundation to the Prussian ministry for a position as exchange teacher during the coming year. Should the appointment be approved by the Prussian Bureau, Mr. Fischer expects to spend the coming year in the careful study of German school life, giving particular attention to the education of young women. I trust that arrangements may be made which will enable him to feel while he is in Germany that his position here is secure for him upon return. Such an experience will make him still more valuable as a member of the instructional force of this college.

Miss Michaelides, who for five years has taught most of the French classes of the department, does not expect to return next year. She had become a peculiarly valuable member of the department, and her work, faithful and done with much skill, will not easily be duplicated, because of the unusual privilege she had had of receiving her education largely in France.

Mr. Hensel, after a service of four years, has resigned to accept a position as assistant superintendent of the Presbyterian Hospital in Chicago. Mr. Hensel came to the department as an instructor in German. He has done work as an instructor in English and in literature, and during the past year taught public speaking, and was in general charge of the work in oratory and debating. I feel that the department has never had a more valuable instructor. His quiet, earnest character has been fully appreciated by the student body, as is indicated by the tribute paid him when he left. The students presented him with an appropriately engraved fob. Only the occasional instructor is thus honored. It is a misfortune that the college does not retain men of such exceptional character, influence and teaching ability, no matter what the financial outlay may be. Other instructors equally good as teachers may be obtained; to obtain others whose influence will be so ennobling and uplifting will not be easy.

During this year the students arranged for a triangular debate with the State Normal College at Ypsilanti and with Alma College. The question discussed was, "Resolved, That the federal government should impose a graduated income tax, constitutionality conceded." In the debate held at Alma on May 17 the negative of the question was upheld by Messrs. R. M. Snyder, '14; P. J. Vevia, '15, and D. L. Clute, '15. Mr. Snyder is an agricultural student and the two freshmen are engineers. The decision in this debate was in favor of Alma. In the debate held

at home on June 8th the affirmative of the question was upheld by Messrs. G. Cochran, '14; E. Hart., Jr., '14, and A. I. Margolis, '14, all agricultural students, the negative being defended by Ypsilanti. The decision of the judges at this debate was favorable to our team. The judges were Superintendent F. B. Buck of St. Johns; E. F. Bishop, Esq., of Lansing, and Hon. L. T. Hemans of Mason. To these gentlemen we wish to express in this public way our appreciation.

The annual oratorical contest was won by Mr. A. I. Margolis, who represented the college at the state contest held at Olivet. The Annual Peace Contest was won by Mr. W. Aisenstein. Through a misunderstanding, however, he did not speak at the state contest, which was held at this college. The State Peace Contest was won by the representative from Ann Arbor, Mr. P. B. Blanshard, who was also successful in winning the interstate contest. The freshman oration contest, which was participated in by eight young men, was won by Mr. G. J. Warnshuis. The sophomore contest was unfortunately called for at a time when students were very busy, with the result that it was found wise not to hold the contest this year. An attempt was made to bring about a contest in reading, open only to freshman women. It was found impossible, however, to hold this contest for a reason similar to that given just above. It is certainly to be hoped that these contests may be continued in the future.

The new arrangement by which the State Board has agreed to finance the public speaking contests through money appropriated to this department will certainly add very much to the possibility of holding successful contests. When the probabilities were that the instructors or the students would have to pay any bills incurred in holding a contest, the enthusiasm to bring about contests was far from great. Every student representing the institution in an intercollegiate contest should receive a fob or some kind of award corresponding to the monogram bestowed upon athletes. In like manner students winning local contests should receive a less valuable fob or other suitable reward.

Perhaps one-third of the freshmen coming to us from the high schools of the state have been too carelessly trained in the use of oral and written English. They regularly make the common grammatical errors in the use of irregular verbs and unwarranted contractions. They do not spell well. They do not use quotation marks and the apostrophe properly. At least one-tenth of the freshmen are not sure about the use of terminal punctuation.

This condition is difficult for the department to handle. The hours of the student here are so fully occupied that it seems impossible to get together students thus deficient and give them the kind of drill which they need. The department has endeavored for two or three years to make arrangements that would care for this deficiency. So far no satisfactory plan has been devised. If such students could be conditioned in their freshman English until these errors have been permanently corrected, and if a time could be found when they could be brought together for the drill necessary to bring about this aim, we should less seldom have seniors graduating who in some respects are little honor to the college in their use of oral and written English. I urge that next year the faculty co-operate in some way with my successor to bring about a reform in this matter. Throughout the year

I have tried to find time to bring this condition before the high school principals and English teachers of the state, as I feel it should be reformed primarily in the high school. The duties of the department, however, have been so heavy that I have been unable to prepare the necessary statements to put before the teachers of the state. I may get this done during the summer. If I fail to accomplish it I believe that it should be done in the near future by my successor. I have discussed the matter with practically all the college English teachers of the state and their conclusions are in harmony with my own. Until the high schools, however, are able to care for the condition, in some way the colleges must care for it in justice to students and to their reputation. It is little short of a disgrace to a college to graduate men and women who are careless in their use of oral and written English. Parenthetically, I might add that department heads will do well to warn every instructor against the use of careless English. Students often quote instructors as using incorrect forms, saying that if men employed by the college for class room work use these forms they see no reason why they themselves should be criticized for using them.

Again I wish to urge the wisdom of making a separate department of modern languages. The work cared for by the head of this department during the last few years since the college has increased so largely in attendance has been so heavy as to make practically impossible the study and reading necessary to carry on class work satisfactorily. The office work has been sufficient to occupy his entire time and attention if he had been entirely without classes to teach. The college will continue to grow; the work of the department will continue to increase. For the good of the college it is really necessary that the modern languages should be placed under a separate head. The economy of the present plan is assuredly a false economy. I trust that the opportunity presented by the resignation of the head of the department will be embraced by the proper authorities and that two departments in the future will serve the necessities that until this time in the history of the college have been served by one. As I cannot profit by any such action, I can urge it with a freedom which up to this time I have not felt. In justice to the student body, and in justice to the man who shall succeed to my position, the department should be divided without delay.

I trust that the State Board will soon reach a decision concerning the future of College Hall. If it is to continue as the center of the work in English and modern languages, it should receive the restoration and renewal which it has so long needed. Classes meeting in a cheerful and modern class room have a distinct advantage over those meeting in the dingy rooms of College Hall. If I may express a personal sentiment, I feel that College Hall should by all means be retained. To raze it would, I feel, be little short of sacrilege. The first building devoted to agricultural education in the United States should be retained as a mile-stone in educational progress and in the modern forward movement of the first and most important pursuit of man. One visiting the campus of Harvard or of Yale cannot but stand in reverence before certain of their ancient and venerable buildings. In another half century a similar spirit of solemnity must inspire the visitor to this campus as he views the classic architectural lines of old College Hall. Once gone it can never be regained. Without delay I feel that

the building should be put into the best possible repair, no matter what the cost, for the sake of its associations. I suppose no student has ever graduated from the institution who has not done work in College Hall. Future records perhaps should be the same; at least the building should be preserved and should be devoted to some use which will make every student a more or less frequent visitor to it. I believe in progress; I believe in new and splendid buildings adequately equipped; but with our broad acres of beautiful campus there can be found for the new central building that is your plan a site that will be satisfactory, even though it may not be so entirely fitting as would be the site of College Hall. Let sentiment reign in this single case and let the building be restored and jealously guarded as sacred because of its unnumbered associations. Vocational education at this place may well have its almost wholly materialistic tendencies modified and embellished by this bit of color from a noble historical past.

I write these last lines of my final report with an overwhelming appreciation of the support this department has had from the faculty during the years which I have been here. The work in English in a technical institution is too often held in slight esteem by the faculty at large. Here there has been a practically unanimous feeling of its importance and of its real worth. When the college course of study has been changed there has never been a serious attempt to cut down the amount of work in English. Requests that I have made concerning the English work have almost invariably been granted without discussion. One thing has not yet been done, which I believe should be done as an aid to my successor, namely, some kind of floating credits should be devised which can be granted as elective credits to students who represent the institution in intercollegiate contests. Athletes get their drill credits for their work on the college field. A plan to excuse from drill, debaters and others engaged in intercollegiate public speaking contests, or to give them some definite credit for this work, without requiring this department or the Department of History and Economics to give credit for work which has really never been done should be worked out. For all that has been done, however, and for the spirit of helpfulness and enthusiastic support which has characterized my colleagues, I am most grateful.

The instructors in the department during the past year have been exceptionally faithful to their work. During some years I have felt as though an occasional instructor was working for his monthly pay rather than for the good of his classes. This year there has been present in every instructor an enthusiasm and a devotion to his work which has made this thought impossible. Their co-operation is a source of deep satisfaction to me, and to feel that I shall not take up the work again with them another year, a source of real regret.

To the State Board, and to you, Mr. President, I wish to express my gratitude and appreciation for your constant willingness to uphold and better the work of the department. In equipment you have granted whatever I have asked for during the six years that I have been here. So, too, the loyalty of your support of the work in the department has been unlimited. To decide to go elsewhere was not easy. I shall never

find a field of labor more congenial. For my successor I can ask nothing better than the treatment uniformly accorded to me.

Very respectfully yours,

THOS. C. BLAISDELL,

Professor of English and Modern Languages.

East Lansing, June 30, 1912.

REPORT OF THE DEPARTMENT OF ENTOMOLOGY.

President J. L. Snyder:

Dear Sir—Following is a brief report of the work of the department for the year ending June 30, 1912.

Seven regular courses in entomology have been given during the year, Course V being given throughout the entire year. Besides this two courses were given to short course students during the winter term. Course VII, Forest Entomology, was given for the first time during the summer of 1911, at the summer camp near Alba.

The work of the department requires little comment. Good-sized classes were registered in all the courses, and little has occurred to interfere with carrying out plans as originally made.

The personnel of the department has remained the same as during the year 1910 and 1911. Miss Eugenia McDaniel devotes half her time to teaching, and the writer gives somewhat more than half his time to like work. Dr. G. D. Shafer has helped out in emergencies and has taught in some of the large classes besides doing most of the field work in the class in the summer school of forestry. Mr. P. W. Mason, now a graduate, has helped out with the laboratory instruction and in other ways, and made it possible to conduct large sections with our present small force of teachers. As he leaves soon, some plan will have to be made to accomplish similar results next year.

As in the past, much material is coming in all the time and the care of this, together with its preparation for class use and for demonstration, occupies all spare time.

It gives me great pleasure to report a year pleasantly passed.

Respectfully submitted,

R. H. PETTIT,

Professor of Entomology.

East Lansing, June 30, 1912.

REPORT OF THE DEPARTMENT OF HISTORY AND ECONOMICS.

President J. L. Snyder:

Sir—I have the honor of submitting the following report concerning the work of this department for the year 1911-12:

The total number of enrollments in the department for the year equalled 836, distributed as follows:

By terms: Fall, 231; winter, 368; spring, 237.

By classes: Freshman, 128; sophomore, 384; junior, 212; Senior, 112.

By subjects: History, 176; economics, 508; political science, 152.

The total number of hours taught during the year by members of the department were 1,551, divided among the three terms as follows:

Fall term, 403; winter, 576; spring, 572.

By subjects the number of recitation hours during the year equalled, economics, 901; history, 345; political science, 315.

The reduction in the number of subjects offered by the curriculum in this college, which was accomplished by faculty action last year and by which a student may now finish with 240 credits instead of 300, as was formerly the case, affected this department in several ways. Upon the whole the outcome has been beneficial, since the work given by this department this year was more effective through being more unified than under the old curriculum. On the other hand, the effects of the elimination of several subjects from the list presented by this department, and these from among the subjects given in the earlier college classes where the numbers are large, have been to greatly reduce the enrollments as compared with other years. We believe that the definiteness and coherency from which the college curriculum as a whole has benefited through having the many subjects eliminated or rearranged, by which the weekly work offered was reduced from 25 to 20 hours, will produce equally good results in this department through the cutting down which has taken place. The perceptibly stronger work that students are able to present in the class rooms through not having their time absorbed in mere class room attendance, as was the situation under the old 25-hour per week schedule, vindicates satisfactorily the new system.

The departments of economics in the various land grant colleges have for some years past met a growing demand for economic information specialized along the lines of agriculture. It has been felt that there are economic problems peculiar to the agriculturist, such as those of farm organization, agricultural credit, markets and transportation facilities, and that specific instruction should be given upon these subjects. Further than this from a pedagogical standpoint some of these subjects, such as that for example of farm organization, offer admirable material in the way of concrete illustrations for class room work. This matter of farm organization, or farm management, as it is sometimes called, which is strictly an economic problem, necessitates the making of farm surveys and the study of systems of farm costs keeping and in many other ways brings the student in touch with actual conditions.

The somewhat abstract subject of economics is in this way given a concreteness and reality for teaching purposes. The worth of this concreteness has been ascertained to some extent by this department through presenting during several years past the subject of environmental resources as a preliminary to elementary economics and the experience gained here and the demand for the subject seemed to warrant the offering of a course in Agricultural Economics for the next year.

The subject matter of the new course is here given as presented in the college catalog, "Agricultural economics is an advanced course which makes specific application of economic principles to the problems of agriculture. Farm organization, markets and transportation and credit facilities and the social aspects of farming are the chief questions discussed. Lectures and text book." The subject requires as a prerequisite Economics 4 and is given 2 hours per week during the fall term.

The material equipment of the department has been added to but slightly during the past year. Some historical pictures were purchased during the early part of the year and were framed and put upon the walls of the class room. Some copies of excellent historical photographs, and a large Stanford, Orographical map of North America have also been procured. The department has also found a plan for securing illustrative material of an economic and historical character for class room walls having the merit of necessitating no costs of any sort. This is through the use of the framed illustrations employed for advertising purposes by railroads and many large industrial enterprises. Through the kindness of Mr. Frank Hendrick, of Detroit, several of these advertising pictures have been sent prepaid to the college.

The administrative duties of a general or college character which have increased so rapidly in recent years through the growth in number of college students are not directly assumed by the different departments as departmental functions; nevertheless they consume so much time of the department members that some mention of them seems imperative in a departmental report. Mr. Ryder, my associate, for example, in addition to carrying on his regular work in history and political science is also the class officer for the freshman class, a member of the permanent committees on excess credits in the Agricultural course and in the Home Economics course, and, during the winter term of this year, was acting secretary of the faculty.

As class officer he had general supervision over approximately 200 freshmen, holding conferences with such members as needed guidance or encouragement, keeping account of their credits or deficits and performing the work of classifying them at the beginning of each term. His work upon the two standing committees consisted chiefly of not infrequent consultations. The labors of the class officer became steadily more difficult, not only on account of the growth in size of the various classes, but also on account of a growing tendency on the part of some teachers to throw class room discipline to some extent upon these officers. The responsibility at any rate has become so large that it may easily be estimated that for the large classes at least fully a quarter of a class officer's working hours is taken up with administrative duties.

The administrative duties which have fallen to the head of the department are the chairmanship of the social committee and, until re-

cently, the general supervision of the college co-operative book store. The social committee of three faculty members has general charge through the direction of a few rather vague faculty rules and a number of traditions, of the social events among the college students. The limited facilities upon the campus for social affairs of a large size, consisting as they do of only the armory and the assembly rooms in the Agricultural Building, throws at once upon this committee the task of allocating these places to the various organizations which may ask for them. The social committee is also required by the faculty to see that each organization provides for itself patrons at its social gatherings and this brings all these groups into consultation with the committee. The character of the entertainment which students provide for themselves changes not a little from year to year and much time is required from the social committee in adjusting details of the new social development into harmony with the established rules.

The book store position has been one of responsibility rather than one which exacted care and time. This enterprise originated as a student and faculty co-operative activity more than 16 years ago, and, from being one of several student or faculty chosen directors of the undertaking, the writer found himself, 7 or 8 years ago, the only one left. From 1905 until the present year the position of residual director left the general responsibility for the business upon myself, although the extremely efficient direct managerial skill of the person in charge, Miss Lillian Kendall (now resigned), left little else of arduousness than responsibility. The undertaking has grown from a business of two or three thousand dollars during its first year to one of approximately $26,000 at the present time, and its control within the last year has been properly shifted from a single person to a stock company composed of members of the faculty.

The membership of the department has changed in but one instance from that which was retained from last year. Shortly before the beginning of the new school year Mr. Don Stevens, instructor in Economics, resigned his position in order to enter business. Mr. Charles Dunford, A. M., who had been engaged in the Economics department at the University of Michigan the preceding year, was employed to fill the vacancy. Mr. Dunford was given the classes of Engineers in Economics and Political Science and a Home Economics class in Sociology, and has proven satisfactorily efficient and capable as a teacher. Mrs. Hendrick was given classes in History, Political Science and Sociology, and although inexperienced as a teacher of this latter subject, a good knowledge of teaching and industrious outside preparation have enabled her to present the course in Sociology with the same satisfactoriness with which her other courses are presented. It is a pleasure to commend the faithfulness, ability and industry of each of these assistants who have helped me in the department.

Yours respectfully,

WILBUR O. HEDRICK,

Professor of History and Economics.

East Lansing, Mich., June 30, 1912.

REPORT OF THE LIBRARIAN.

President J. L. Snyder:

Dear Sir—I have the honor to present the following report on the library for the year ending June 30, 1912:

There have been added to the library during the year 1,438 bound volumes, of which 506 were purchased, 770 came by binding, and 162 were presented to us. We have also received 1,681 unbound volumes and pamphlets, all of which were duly acknowledged when received if the donor was known.

For bound volumes donated to the library we are indebted as follows:

American Yorkshire Club, 3.
American Saddle-horse Breeders' Ass'n., 1.
Christian Science Church of Lansing, 1.
Canada, 14.
Dutton, E. P., 1.
Graves, A. P., 1.
Hedges, J. E., 1.
Hedrick, Dr. W. O., 1.
Hampshire Down Ass'n., 1.
Indiana, 4.
Iowa, 7.
Iowa Academy of Science, 3.
Kawada, Y., 1.
Kansas, 2.
Lyman, Dean R. P., 1.
Maine, 1.
Massachusetts, 2.
Missouri, 3.
Missouri Botanical Gardens, 1.
McInnes, Mrs., 2.
Marshall, Dr. C. E., 1.
Michigan, 37.
Michigan Academy of Science, 1.
N. Y. Education Dept., 10.
N. Y. Public Service Dept., 10.
No. Carolina, 1.
No. Dakota, 1.
National Lumberman's Ass'n., 2.
New England News Co., 1.
Smithsonian Institution, 1.
Smithsonian Institution United States National Museum, 6.
U. S. Agricultural Dept., 7.
Education Bureau, 5.
Interstate Commerce Com., 1.
Labor Bureau, 7.
Navy Dept., Bureau of Equipment, 7.
War Dept., 1.
University of Michigan, 1.
Wellcome Laboratories, Khartoum, Egypt, 1.
West Virginia, 1.
Wisconsin, 2.

(We do not include in the above, the publications received from the Supt. of Documents, which are in storage in the Agricultural Building.)

In the reading room are placed about 500 periodicals and newspapers, foreign and American, which are either purchased by the college, or received from publishers as gifts, or in exchange for our own publications. The titles of donations and exchanges are as follows:

Adrian Times.
Agricultural Gazette of N. S. Wales.
Agricultural Advertising.
Agricultural Students' Gazette, England.
Allegan Gazette.
American Cheesemaker.
American Economist.
American Missionary.
American Poultry Advocate.
American Sheepbreeder.

American Sugar Industry.
American Swineherd.
American Thresherman.
Arboriculture.
Agricultural Ledger, Calcutta, India.
Ann Arbor Argus.
Armada Graphic.
Arrow, The.
Australiasian.
Bay City Times.
Battle Creek Journal.
Bear Lake Beacon.
Belding Banner.
Berkshire World and Corn Belt Stockman.
Better Fruit.
Bulletin of the College of Agriculture, Tokio.
Chicago Live Stock World.
Canadian Farm.
Church Helper.
Canadian Horticulturist.
Cattle Specialist.
Chicago Daily Farmers' and Drovers' Journal.
Chicago Packer.
Christian Herald.
Columbia University Quarterly.
Congressional Record.
Daily Drovers' Journal and Stockman, Omaha.
Dakota Farmer.
Electrical Times.
Economic Bulletin.
Farm and Fireside.
Farm and Home.
Farm Life.
Farm News.
Farm World.
Farmers' Advocate.
Farmers' Guide.
Farmers' Voice.
Florists' Exchange.
Garden.
Garden Magazine.
Gleaner.
Gleanings in Bee Culture.
Good Health.
Grand Ledge Independent.
Hawaiian Forester.
Hillsdale Leader.
Hillsdale Standard.
Hoard's Dairyman.
Holstein-Friesian Register.
Holstein-Friesian World.
Home and Farm.
Homestead.
Horseshoers' Journal.
Horse World.
Improvement Era.
India, Dept. of Agriculture, Report.
Memoirs (Botanical series). Research Inst., Pusa.
Memoirs (Entomological series).
Agri. Journal of India Series, Pusa.
Indian's Friend.
Indiana Farmer.
Illuminating Engineer.
Iowa Horticulture.
Journal of the College of Agriculture, Tokio.
Jamaica Dept. of Agriculture, Bulletin.
Jenner (now Lister) Institute of Preventive Medicine.
Jersey Bulletin.
Johns Hopkins Univ. Circulars.
Journal of Agriculture, Australia.
Journal of Agriculture, Victoria.
Journal of the Board of Agri. and Fisheries, England.
Kalamazoo Telegraph.
Kansas Farmer.
Kimball's Dairy Farmer.
Labor Digest.
Lawton Leader.
Lewiston Journal.
Live Stock Journal.
Live Stock Report.
Mark Lane Express.
Michigan Dairy Farmer.
Michigan Farmer.
Michigan Mirror.
Michigan Presbyterian.
Midland Farmer.
Milchwirtschaftliches Centralblatt.
Moderator-Topics.
National Stockman and Farmer.

N. Y. Meteorology. (Draper's Hourly reading.)
N. Y. Produce Review.
Ohio Farmer.
Official Gazette, U. S. Patent Office.
Orange Judd Farmer.
Oregon Agriculturist.
Owosso Press American.
Poultry Keeper.
Practical Dairyman.
Park and Cemetery.
Philippine Agrl. Review.
Practical Farmer.
Publicity Magazine.
Records of the Australian Museum.
Redman.
Reliable Poultry Journal.
Republic, Rockefeller Institute for Medical Research, Studies.
Rural Advocate.
Rural New Yorker.
Southern Farm Magazine.
Saginaw Evening News.
State Journal, Lansing.
Southern Cultivator.
Special Crops.
Successful Farming.
Twentieth Century Magazine.
Tuscola County Advertiser.
Western Society of Engineers, Journal.
Wallace Farmer.
Washington Acad. of Sciences, Proceedings.
Weather Review.
Wilson Bulletin.
Writer.

The publications of the United States Department of Agriculture, and the bulletins of the various state experiment stations, together with the card indexes which cover them, are received and filed in the library. We also receive and file the catalogs of the leading educational institutions of the country.

The number of books taken from the library for home use during the year was 7,848. The largest number borrowed during any month of the year was 967, and the smallest number borrowed was 107,—the months of February and August respectively. Fines to the amount of $32.30 have been collected during the year and placed to the credit of the library.

The library hours have remained unchanged, and for our assistant, Miss Bessie Palm, and our student assistant, Mr. R. E. Duddles, we have only words of commendation for the conscientious performance of duty.

To the library of the Experiment Station have been added 236 bound volumes of which 121 were purchased, 4 were gifts, and 111 came by binding.

The college library now numbers 31,075 bound volumes, and the experiment station library contains 4,427 volumes. Total in both libraries, 35,502 volumes. This number includes all books belonging to departments so far as they have catalogued.

Respectfully submitted,

LINDA E. LANDON,
Librarian.

East Lansing, June 30, 1912.

REPORT OF THE DEPARTMENT OF MATHEMATICS.

President J. L. Snyder:

Dear Sir—The teaching staff of the Department of Mathematics for the college year 1911-12 consisted of the following named men, given in order of seniority of appointment:

Warren Babcock, B. S., Professor of Mathematics.
M. F. Johnson, B. S., Instructor.
S. E. Crowe, B. A., Instructor.
J. E. Robertson, B. S., Instructor.
E. E. Beighle, B. S., Instructor.
L. C. Emmons, B. S., Instructor.
K. E. Hopphan, B. S., Instructor.
H. A. Snepp, A. B., L.L. B., Instructor.
R. H. Reece, B. S., Instructor.

Owing to the stress of class work during the fall and winter terms, it became necessary to secure extra help. Mr. E. E. Sours taught three sections in each of the first two terms—fall and winter.

Again we have been fortunate in being able to retain the complete staff of the previous year, thus adding materially to the efficiency of the department.

I present herewith a schedule of class room work for the year.

Fall Term, 1911.

Class.	Subject.	No. of course.	Instructor.	Classroom.	Hour of meeting.	No. of hrs. per week.	No. of students in class.
Sub-fresh	Plane Geom.	Math. 2a	Mr. Hopphan	100 Ag. Hall	10:45-11:40	5	9
Sub-fresh	Plane Geom.	Math. 2a	Mr. Snepp	101 Ag. Hall	9:50-10:45	5	16
Sub-fresh	Plane Geom.	Math. 2a	Mr. Crowe	101 Ag. Hall	12:40- 1:35	5	17
Sub-fresh	Plane Geom.	Math. 2a	Mr. Crowe	8 College Hall	2:30- 3:25	5	17
Sub-fresh	Plane Geom.	Math. 2a	Mr. Reece	100 Ag. Hall	12:40- 1:35	5	16
Sub-fresh	Plane Geom.	Math. 2a	Mr. Reece	2 College Hall	2:30- 3:25	5	18
Sub-fresh	Plane Geom.	Math. 2a	Mr. Johnson	8 College Hall	12:40- 1:35	5	18
Sub-fresh	Plane Geom.	Math. 2a	Prof. Babcock	2 College Hall	9:50-10:45	5	15
Sub-fresh	Plane Geom.	Math. 2a	Mr. Sours	100 Eng. Hall	10:45-11:40	5	11
Sub-fresh	Ag. and W. Alg.	Math. 1	Mr. Beighle	102 Ag. Hall	10:45-11:40	5	14
Sub-fresh	Ag. and W. Alg.	Math. 1	Mr. Robertson	8 College Hall	8:55- 9:50	5	12
Sub-fresh	Ag. and W. Alg.	Math. 1	Mr. Robertson	101 Ag. Hall	10:45-11:40	5	14
Sub-fresh	Ag. and W. Alg.	Math. 1	Mr. Hopphan	100 Ag. Hall	2:30- 3:25	5	22
Sub-fresh	Ag. and W. Alg.	Math. 1	Mr. Crowe	2 College Hall	8:55- 9:50	5	11
Sub-fresh	Eng. Alg.	Math. 1e	Mr. Snepp	100 Ag. Hall	8:55- 9:50	5	17
Sub-fresh	Eng. Alg.	Math. 1e	Mr. Johnson	8 College Hall	1:35- 2:30	5	21
Freshmen	Eng. Alg.	Math. 1e	Mr. Beighle	102 Ag. Hall	3:25- 4:20	5	19
Freshmen	Eng. Alg.	Math. 1e	Mr. Robertson	8 College Hall	8:00- 8:55	5	19
Freshmen	Eng. Alg.	Math. 1e	Mr. Hopphan	100 Ag. Hall	3:25- 4:20	5	19
Freshmen	Eng. Alg.	Math. 1e	Mr. Crowe	2 College Hall	8:00- 8:55	5	19
Freshmen	Eng. Alg.	Math. 1e	Mr. Emmons	208 Ag. Hall	10:45-11:40	5	22
Freshmen	Eng. Alg.	Math. 1e	Mr. Reece	2 College Hall	3:25- 4:20	5	17
Freshmen	Eng. Alg.	Math. 1e	Mr. Johnson	100 Ag. Hall	8:00- 8:55	5	20
Freshmen	Ag. and W. Alg.	Math. 1b	Mr. Beighle	102 Ag. Hall	9:50-10:45	5	22
Freshmen	Ag. and W. Alg.	Math. 1b	Mr. Beighle	102 Ag. Hall	2:30- 3:25	5	23
Freshmen	Ag. and W. Alg.	Math. 1b	Mr. Robertson	8 College Hall	3:25- 4:20	5	23
Freshmen	Ag. and W. Alg.	Math. 1b	Mr. Hopphan	100 Ag. Hall	1:35- 2:30	5	26
Freshmen	Ag. and W. Alg.	Math. 1b	Mr. Snepp	2 College Hall	1:35- 2:30	5	22
Freshmen	Ag. and W. Alg.	Math. 1b	Mr. Snepp	101 Ag. Hall	3:25- 4:20	[illegible]	[illegible]
Freshmen	Ag. and W. Alg.	Math. 1b	Mr. Emmons	101 Ag. Hall	8:00- 8:55	5	18
Freshmen	Ag. and W. Alg.	Math. 1b	Mr. Emmons	100 Ag. Hall	9:50-10:45	5	23
Freshmen	Ag. and W. Alg.	Math. 1b	Mr. Emmons	101 Ag. Hall	2:30- 3:25	5	23
Freshmen	Ag. and W. Alg.	Math. 1b	Mr. Reece	102 Ag. Hall	8:00- 8:55	5	17
Freshmen	Ag. and W. Alg.	Math. 1b	Mr. Reece	103 Ag. Hall	9:50-10:45	5	24
Freshmen	Ag. and W. Alg.	Math. 1b	Mr. Johnson	8 College Hall	9:50-10:45	5	21
Freshmen	Ag. and W. Alg.	Math. 1b	Mr. Sours	301 Eng. Hall	3:25- 4:20	5	21
Freshmen	Ag. and W. Alg.	Math. 1b	Mr. Sours	203 Eng. Hall	8:00- 8:55	5	17
Sophomores	Anal. Geom.	Math. 5	Mr. Robertson	2 College Hall	12:40- 1:35	5	[illegible]
Sophomores	Anal. Geom.	Math. 5	Mr. Snepp	102 Ag. Hall	12:40- 1:35	5	21
Sophomores	Anal. Geom.	Math. 5	Mr. Crowe	100 Ag. Hall	10:45-11:40	[illegible]	[illegible]
Sophomores	Anal. Geom.	Math. 5	Mr. Emmons	100 Ag. Hall	12:40- 1:35	5	22
Sophomores	Anal. Geom.	Math. 5	Mr. Johnson	8 College Hall	10:45-11:40	5	21
Sophomores	Anal. Geom.	Math. 5	Prof. Babcock	2 College Hall	10:45-11:40	5	22

Winter Term, 1912.

Class.	Subject.	No. of course.	Instructor.	Classroom.	Hour of meeting.	No. of hrs. per week.	No. of students in class.
Sub-fresh.....	Ag. and W. Alg....	Math. 1a...	Mr. Emmons......	100 Ag. Hall......	1:35- 2:30	5	20
Sub-fresh.....	Ag. and W. Alg...	Math. 1a...	Mr. Sours.........	102 Ag. Hall......	10:45-11:40	5	20
Sub-fresh.....	Eng. Alg..........	Math. 1d...	Mr. Johnson......	8 College Hall...	1:35- 2:30	5	29
Sub-fresh.....	Eng. Alg..........	Math. 1c...	Mr. Crowe........	101 Ag. Hall......	1:35- 2:30	5	19
Sub. fresh....	Ag. and W. Alg....	Math. 1a...	Mr. Beighle.......	100 Ag. Hall......	9:50-10:45	5	26
Sub-fresh.....	Plane Geom......	Math. 2b...	Mr. Hopphan.....	2 College Hall...	2:30- 3:25	5	18
Sub-fresh.....	Plane Geom......	Math. 2b...	Mr. Robertson....	8 College Hall...	8:00- 8:55	5	19
Sub-fresh.....	Plane Geom......	Math. 2b...	Mr. Robertson	103 Ag. Hall......	1:35- 2:30	5	25
Sub-fresh.....	Plane Geom......	Math. 2b...	Mr. Beighle.......	103 Ag. Hall......	12:40- 1:35	5	26
Sub-fresh.....	Plane Geom......	Math. 2b..	Mr. Reece	8 College Hall...	9:50-10:45	5	29
Freshmen.....	Eng. Alg..........	Math. 1f...	Mr. Crowe	102 Ag. Hall......	8:00- 8:55	5	15
Freshmen.....	Eng. Alg..........	Math. 1f...	Mr. Crowe	101 Ag. Hall......	8:55- 9:50	5	22
Freshmen.....	Eng. Alg..........	Math. 1f...	Mr. Johnson	2 College Hall...	8:00- 8:55	5	19
Freshmen.....	Eng. Alg..........	Math. 1f...	Mr. Beighle.......	100 Ag. Hall......	12:40- 1:35	5	21
Freshmen.....	Eng. Alg..........	Math. 1f....	Mr. Snepp........	101 Ag. Hall......	3:25- 4:20	5	18
Freshmen.....	Eng. Alg..........	Math. 1f....	Mr. Emmons......	100 Ag. Hall......	8:00- 8:55	5	18
Freshmen.....	Eng. Alg..........	Math. 1f....	Mr. Hopphan.....	2 College Hall...	3:25- 4:20	5	21
Freshmen.....	Solid Geom.......	Math. 2c...	Mr. Hopphan.....	2 College Hall...	10:45-11:40	5	24
Freshmen.....	Solid Geom.......	Math. 2c...	Mr. Hopphan.....	301 Eng. Hall.....	12:40- 1:35	5	16
Freshmen.....	Solid Geom.......	Math. 2c...	Mr. Emmons......	120 Eng. Hall.....	3:25- 4:20	5	15
Freshmen.....	Solid Geom.......	Math. 2c...	Mr. Snepp........	101 Ag. Hall......	9:50-10:45	5	13
Freshmen.....	Solid Geom.......	Math. 2c...	Mr. Sours.........	102 Ag. Hall......	9:50-10:45	5	14
Freshmen.....	Solid Geom.......	Math. 2c...	Mr. Sours.........	102 Ag. Hall......	8:00- 8:55	5	24
Freshmen.....	Solid Geom.......	Math. 2c...	Mr. Reece.........	8 College Hall...	3:25- 4:20	5	16
Freshmen.....	Ag. Trig..........	Math. 4a...	Mr. Hopphan.....	100 Ag. Hall......	8:55- 9:50	3	17
Freshmen.....	Ag. Trig..........	Math. 4a...	Mr. Robertson....	8 College Hall...	8:55- 9:50	3	16
Freshmen.....	Ag. Trig..........	Math. 4a...	Mr. Robertson....	102 Ag. Hall......	12:40- 1:35	3	24
Freshmen.....	Ag. Trig..........	Math. 4a...	Mr. Snepp........	101 Ag. Hall......	10:45-11:40	3	22
Freshmen.....	Ag. Trig..........	Math. 4a...	Mr. Snepp........	103 Ag. Hall......	2:30- 3:25	3	21
Freshmen.....	Ag. Trig..........	Math. 4a...	Mr. Beighle.......	100 Ag. Hall......	10:45-11:40	3	21
Freshmen.....	Ag. Trig..........	Math. 4a...	Mr. Beighle.......	100 Ag. Hall......	2:30- 3:25	3	22
Freshmen.....	Ag. Trig..........	Math. 4a...	Mr. Johnson......	2 College Hall...	8:55- 9:50	3	17
Freshmen.....	Ag. Trig..........	Math. 4a...	Mr. Reece.........	8 College Hall...	12:40- 1:35	3	24
Freshmen.....	Ag. Trig..........	Math. 4a...	Mr. Reece.........	8 College Hall...	2:30- 3:25	3	21
Sophomores...	Calculus..........	Math. 6a...	Mr. Emmons......	100 Ag. Hall......	12:40- 1:35	5	22
Sophomores...	Calculus..........	Math. 6a....	Mr. Robertson....	2 College Hall...	9:50-10:45	5	17
Sophomores...	Calculus..........	Math. 6a...	Mr. Snepp........	2 College Hall...	12:40- 1:35	5	21
Sophomores...	Calculus.........	Math. 6a...	Mr. Johnson......	111 Eng. Hall.....	10:45-11:40	5	17
Sophomores...	Caluclus.........	Math. 6a...	Mr. Reece.........	8 College Hall...	10:45-11:40	5	19
Sophomores...	Calculus..........	Math. 6a...	Mr. Crowe........	101 Ag. Hall......	12:40- 1:35	5	17

Spring Term, 1912.

Class.	Subject.	No. of course.	Instructor.	Classroom.	Hour of meeting.	No. of hrs. per week.	No. of students in class.
Sub-fresh	Solid Geom	Math. 2c	Mr. Crowe	8 College Hall	8:00- 8:55	5	19
Sub-fresh	Solid Geom	Math. 2c	Mr. Crowe	8 College Hall	8:55- 9:50	5	18
Sub-fresh	Solid Geom	Math. 2c	Mr. Emmons	2 College Hall	8:55- 9:50	5	18
Sub-fresh	Solid Geom	Math. 2c	Mr. Johnson	102 Ag. Hall	8:00- 8:55	5	19
Sub-fresh	Solid Geom	Math. 2c	Mr. Reece	100 Ag. Hall	12:40- 1:35	5	14
Sub-fresh	Solid Geom	Math. 2c	Mr. Johnson	102 Ag. Hall	12:40- 1:35	5	14
Sub-fresh	Mensuration	Math. 3	Mr. Robertson	2 College Hall	1:35- 2:30	5	17
Sub-fresh	Mensuration	Math. 3	Mr. Snepp	8 College Hall	1:35- 2:30	5	17
Freshmen	Eng. Trig	Math. 4b	Mr. Beighle	2 College Hall	8:00- 8:55	5	20
Freshmen	Eng. Trig	Math. 4b	Mr. Beighle	301 Eng. Hall	12:40- 1:35	5	17
Freshmen	Eng. Trig	Math. 4b	Mr. Hopphan	103 Ag. Hall	8:00- 8:55	5	20
Freshmen	Eng. Trig	Math. 4b	Mr. Hopphan	101 Ag. Hall	12:40- 1:35	5	17
Freshmen	Eng. Trig	Math. 4b	Mr. Robertson	2 College Hall	12:40- 1:35	5	15
Freshmen	Eng. Trig	Math. 4b	Mr. Snepp	101 Ag. Hall	8:00- 8:55	5	22
Freshmen	Eng. Trig	Math. 4b	Mr. Reece	100 Ag. Hall	8:00- 8:55	5	19
Sophomores	Calculus	Math. 6b	Mr. Reece	2 College Hall	10:45-11:40	5	17
Sophomores	Calculus	Math. 6b	Mr. Robertson	8 College Hall	10:45-11:40	5	17
Sophomores	Calculus	Math. 6b	Mr. Snepp	8 College Hall	12:40- 1:35	5	20
Sophomores	Calculus	Math. 6b	Mr. Johnson	100 Ag. Hall	10:45-11:40	5	17
Sophomores	Calculus	Math. 6b	Mr. Crowe	100 Ag. Hall	1:35- 2:30	5	19
Sophomores	Calculus	Math. 6b	Mr. Emmons	103 Ag. Hall	12:40- 1.35	5	20

During the year 357 special examinations were given, including 86 in entrance subjects.

An examination of this table will show that there were many less classes in the spring term than in each of the other two—about half as many. This trouble existed with us to some extent during the previous year, but has been greatly aggravated by the new courses put into effect last September. It has become practically impossible to handle the work of the fall and winter terms with the present regular teaching force of the department, and I hope that some readjustment of the courses will be made by which the work may be distributed more evenly throughout the year.

I desire to call your attention to the lack of office room for the members of this department.

Respectfully submitted,

WARREN BABCOCK,

Professor of Mathematics.

East Lansing, June 30, 1912.

REPORT OF THE DEPARTMENT OF MILITARY SCIENCE.

The President, Michigan Agricultural College:

Sir—I have the honor to submit the following report for the year ending June 30, 1912:

With some exceptions the instruction given followed closely along lines pursued in the past. The work at the beginning of the year was hampered somewhat by the late arrival of the new Infantry Drill Regulations, but once under way proceeded satisfactorily.

All cadet staff officers and non-commissioned staff officers whose services were not required at drill were organized into a staff class and assigned a special course of study under the cadet colonel. An additional second lieutenant was appointed in each company, and for all commissioned officers shoulder straps superseded chevrons. Thirty sabers and a number of fine new instruments were added to our equipment.

During the winter term an innovation was undertaken, viz., giving military instruction to short course men. The course covered 7 weeks, 5 hours per week; the drill being in the middle of the afternoon. The results from a military viewpoint were very gratifying. Great interest was shown by the students and their progress was remarkable. Much credit is due the cadet officers of the regular corps who volunteered their services as instructors. The course was given at the request of the Dean of Agriculture with a view of improving the academic work of these students during the later hours of the day, heretofore regarded as practically lost on account of the mental weariness generally prevalent. It was found that this interesting and mildly strenuous diversion accomplished the object sought. On account of the inadequate facilities for indoor instruction it was impossible to extend this work to all who sought it.

The annual War Department inspection was made on May 15th by Captain Harrison Hall, General Staff, U. S. Army. His report has not yet been received but his remarks while here indicated that the Corps had made a very creditable showing. This result was particularly pleasing in view of the fact that the unusual lateness of spring prevented outdoor drill until April 8th and that much of the work attempted—patrolling, outposts, advance and rear guards, and attack—was new to the entire Corps. Of an aggregate of 683 cadets 662 were present, and of the 21 absentees 8 were absent with leave or sick.

In the annual competitive drill first place was awarded to Company "C," Captain W. A. McDonald, second to Company "A," Captain E. C. Douglas, and third to Company "L," Captain M. J. Gearing. The judge on this occasion was Captain Frank L. Wells, 11th U. S. Infantry, Inspector-Instructor, Michigan National Guard, who on May 29th accepted a review of the Corps and presented the medal to the captain of the prize company.

It is regretted that Governor Chase S. Osborn and Brigadier General

P. L. Abbey, Michigan National Guard, were unable to accept reviews tendered them.

The Cadet Band under the able direction of Assistant Professor A. J. Clark completed another year of excellent work. The members deserve the highest commendation for the loyal manner in which they gave their services at concerts, mass meetings, athletic events, and so forth. Their efforts met with much favorable comment.

Sergeant P. J. Cross, U. S. Army, retired, served throughout the year as assistant in a highly loyal and faithful manner, as did also the many cadet officers upon whose interest and efforts the efficiency of the Corps so largely depends.

In conclusion I earnestly renew the recommendations heretofore submitted, viz., that better facilities for both indoor and outdoor instruction be provided at an early date. The drill grounds can be materially enlarged by the removal of 7 or 8 trees now occupying the middle of the field and greatly reducing its usefulness, while an addition to each end of the Armory, as proposed by me during the past year, would greatly relieve the discouraging conditions under which we now carry out the winter program.

Very respectfully,

A. C. CRON,

1st Lieut., U. S. Infantry,

Professor of Military Science and Tactics.

East Lansing, June 30, 1912.

REPORT OF THE DEPARTMENT OF ZOOLOGY AND PHYSIOLOGY.

To the President:

Sir—I have the honor to make the following report on the condition and work of the Department of Zoology and Physiology, and the General Museum, for the year ending June 30, 1912:

But one change has occurred in the teaching staff. Mr. Royal E. Davis, Ripon College, 1911, succeeded Mr. Oscar B. Park as Instructor in Zoology. Owing to the change in courses mentioned later, Mr. Davis' work was confined mainly to physiology and elementary zoology. He will be released at the end of the college year and his successor has not yet been engaged. Mr. H. S. Osler has also tendered his resignation and will be succeeded by Mr. Allen C. Conger, Ohic Wesleyan, 1910.

The classes for the year have been much as in former sessions, but the total number of students handled was slightly smaller than last year. This was due mainly to the restoration of elementary zoology (Zoology 1) to the sophomore year, whence it was removed two years ago against my earnest protest. The present transfer improves conditions materially, but since this course had been given already to the present sophomores when they were freshmen it left the department work very light for the fall term and correspondingly heavy for the winter and spring terms. Of course, this will adjust itself another year. A new

elective course, advanced human physiology (Physiology 3) was offered to the junior and senior women in the fall term, and proved popular and successful. It relates mainly to nutrition and supplies a much needed preparation for the study of dietetics.

UNIVERSITY EXTENSION WORK.

As in former years, the head of the department has done a large amount of gratuitious educational work outside the college proper, making several addresses before schools, societies, women's clubs, etc., and answering hundreds of inquiries from all parts of the state in regard to its wild animal life and its mineral resources. In May a trip was made to Montmorency county to investigate a report of the nesting of wild pigeons there, but only mourning doves were found. For several years rewards of $1,000 to $1,500 have been offered by various societies and individuals for the discovery of a genuine nesting of the passenger pigeon, but without result. There can be no longer the slighest doubt that this species is extinct, not only in Michigan but everywhere.

The little bulletin on Common Michigan Birds (Bull. 37, Dept. Public Instruction), mentioned in my last report, proved very popular and the first edition, 15,000 copies, was soon exhausted. It was republished as a section of "Michigan Specials Days," by the same department, and distributed freely to teachers as long as the supply lasted. It was also reprinted in the annual report of the Superintendent of Public Instruction for 1911, but, the demand still continuing, it is probable that a new edition will be issued during the present summer.

The writer's large work entitled "Michigan Bird Life," which was reported as ready for the printer in my last report, was presented to the State Board of Agriculture in September and was accepted and ordered printed as a special bulletin of the Department of Zoology. It went to the state printer in December and the first bound copies were received during the last week in June. The edition of 10,000 copies is bound partly in cloth, partly in paper. It forms a heavy volume (over 4 pounds) of 822 pages and 222 illustrations, printed from new type on good enameline paper which brings out the half-tones well (there are no colored plates). The cost of the book has been so great that the Board deemed it necessary to restrict its distribution somewhat and have decided that it cannot be supplied *gratis*, but will be sold at actual cost of printing and binding. This fixes the price at the college at 45 cents in paper or 60 cents in cloth, with an extra charge of 35 cents for transportation, which must be prepaid. Applications and money (not stamps) should be sent to Secretary A. M. Brown, East Lansing, not to the author. The book lists and describes 326 species which have been found in Michigan, and contains critical notes on 62 others which have been attributed to the state but which for one reason or another are not admitted. The author has attempted to give a brief but accurate description of the life history of every bird found in the state, combining popular and scientific information in such a way as to make it intelligible to the layman as well as useful and satisfactory to the specialist. How nearly this object has been attained time alone can show; the book must speak for itself.

THE GENERAL MUSEUM.

The museum has received constant attention during the year, but the general rearrangement and installation of uniform labels was postponed until two new cases could be built to provide for some of the valuable accessions which otherwise must be stored away. Among recent accessions should be mentioned a second collection of more than 50 specimens of the birds and mammals of Chili, from D. S. Bullock; a fine mounted specimen of muskallunge caught in Georgian Bay by the late Hugh Lyons of Lansing, and a good mounted specimen of the rare wingless New Zealand bird, *Apteryx oweni*, purchased. The new cases will be finished and filled during the summer vacation.

Public interest in the museum has increased steadily and its educational value, both to students and the people at large, can hardly be overestimated.

Respectfully submitted,
WALTER B. BARROWS,
Professor of Zoology and Physiology and
Curator of the General Museum.

East Lansing, June 30, 1912.

REPORT OF THE DEPARTMENT OF METEOROLOGY.

President J. L. Snyder:

Dear Sir—I have the honor to submit the following report of the Department of Meteorology:

The course which was presented during the fall term of 1910 was repeated in the fall term of 1911, as a junior and senior elective study. Forty-seven students were enrolled.

This number of students is too large for the most successful laboratory work, and the instrumental equipment available is not sufficient for so large a number. It is recommended that arrangements be made to repeat the course in the spring term in order to decrease the size of the class. While this would increase the work of the instructor I am sure the results would be more satisfactory to both students and instructor. A course especially adapted for forestry students might be given in the fall term and one more suited to agricultural students in the spring.

Through the kindness of Dean R. S. Shaw and Prof. Jos. A. Jeffery of the Soils department, the department again was allowed the use of a spacious lecture room and laboratory in the Agricultural Building.

Very respectfully,
DEWEY A. SEELEY,
Instructor in Meteorology.

East Lansing, June 30, 1912.

METEOROLOGICAL TABLES.

Meteorological observations for the month of January, 1911, at Agricultural College, East Lansing, Michigan.

Date.	Temperature. (Degrees Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. (In inches and hundredths.)	Character of day.	Snow on ground. (Inches.)
1	38	27	32	.15	Cloudy	7.0
2	40	13	26	0	Cloudy	6.8
3	17	−1	8	0	Cloudy	6.5
4	14	4	9	.03	Partly Cloudy.	6.5
5	13	0	6	.12	Partly Cloudy.	7.5
6	21	9	15	.03	Cloudy	8.5
7	36	12	24	.02	Partly Cloudy.	8.0
8	37	20	28	.14	Cloudy	6.5
9	27	17	22	0	Clear	6.4
10	42	18	30	0	Clear	6.0
11	42	25	34	.54	Cloudy	4.5
12	34	25	30	0	Partly Cloudy.	4.2
13	33	30	32	.07	Cloudy	4.0
14	34	24	29	.06	Cloudy	3.5
15	28	12	20	0	Partly Cloudy.	3.5
16	18	6	12	0	Partly Cloudy.	3.5
17	22	9	16	0	Clear	3.4
18	31	5	18	0	Clear	3.3
19	30	20	25	0	Cloudy	3.2
20	36	26	31	.01	Cloudy	2.8
21	35	11	23	0	Cloudy	2.5
22	23	6	14	0	Clear	2.4
23	34	15	24	0	Clear	2.2
24	41	21	31	0	Clear	1.0
25	40	35	38	.01	Cloudy	0
26	46	35	40	.05	Cloudy	0
27	46	34	40	.05	Cloudy	0
28	41	30	36	0	Clear	0
29	43	34	38	0	Cloudy	0
30	35	15	25	0	Clear	0
31	29	16	22	.15	Partly Cloudy.	2.2
Mean	32.5	17.8	25.2	Total. 1.43		

Atmospheric Pressure.—(Reduced to sea level; inches and hundredths.)—Mean, 30.12; highest, 30.57; date ,16th; lowest, 29.44; date, 8.

Temperature.—Highest, 46; date, 27; lowest, 1; date, 3; greatest daily range, 27; date ,2; least daily range, 3; date, 13.

Precipitation.—Total this month, 1.43; snowfall, 6.3; greatest precipitation in 24 hours, .54; date, 11; Snow on the ground at end of month, 2.2.

Wind.—Prevailing direction, southwest; total movement, 6147 miles; average hourly velocity, 8.3; maximum velocity (for five minutes) 34; miles per hour, from northwest on 30.

Weather.—Number of days, clear, 9; partly cloudy, 7; cloudy 15; on which .01 inch, or more, of precipitation occurred, 14.

Miscellaneous Phenomena (dates of).—Auroras, 0; halos: solar, 5, 7, 10, 12, 16, 17, 21, 31; lunar, 10; hail, 0; sleet, 25; fog, 26, 27; thunderstorms, 0. *frost: light, 0; heavy, 0; killing, 0.

*Frosts are not recorded after the occurrence of "killing," except in Florida and along the immediate coast of the Gulf of Mexico.

DEWEY A. SEELEY,
Local Forecaster, Weather Bureau.

Meteorological observations for the month of February, 1911, at Agricultural College, East Lansing, Michigan.

Date.	Temperature. (Degrees Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. (In inches and hundredths.)	Character of day.	Snow on ground. (Inches.)
1	33	18	26	0	Cloudy	1.8
2	39	17	28	0	Partly Cloudy.	0.8
3	31	18	24	0	Cloudy	0.5
4	32	18	25	0	Cloudy	0
5	20	11	16	.20	Partly Cloudy.	0
6	18	10	14	.54	Cloudy	6.0
7	25	12	18	.01	Clear	6.0
8	34	17	26	0	Partly Cloudy.	4.5
9	32	14	23	.02	Partly Cloudy.	4.5
10	28	8	18	0	Cloudy	4.0
11	42	7	24	0	Clear	3.0
12	37	34	36	0	Cloudy	2.3
13	37	34	36	.07	Cloudy	1.0
14	37	33	35	.47	Cloudy	0
15	37	32	34	0	Cloudy	0
16	45	32	38	.13	Cloudy	0
17	54	33	44	.22	Cloudy	0
18	35	27	31	.03	Partly Cloudy.	0.3
19	27	17	22	.01	Cloudy	0
20	29	13	21	.02	Cloudy	0
21	26	7	16	.01	Partly Cloudy.	0
22	33	19	26	0	Partly Cloudy.	0
23	42	17	30	0	Clear	0
24	43	28	36	0	Clear	0
25	50	32	41	0	Clear	0
26	42	31	36	.04	Cloudy	0
27	31	19	25	0	Partly Cloudy.	0
28	28	18	23	0	Clear	0
Mean	34.5	20.6	27.6	Total. 1.77		

Atmospheric Pressure.—(Reduced to sea level; inches and hundredths).—Mean, 30.10; highest, 30.60; date, 27; lowest, 29.62; date, 14.

Temperature.—Highest, 54; date, 17; lowest, 7; date, 11; greatest daily range, 35; date, 11; least daily range, 3; date, 13. Mean for this month in 1911, 28.

Precipitation.—Total this month, 1.77; snowfall, 7. 7; greatest precipitation in 24 hours, .74; date, 5 and 6; snow on the ground at end of month, 0.

Wind.—Prevailing direction, west; total movement, 5912 miles; average hourly velocity, 8.8; maximum velocity (for five minutes) 27 miles per hour, from northwest on 2.

Weather.—Number of days, clear 6; partly cloudy, 8; cloudy, 14; on which .01 inch, or more, of precipitation occurred, 13.

Miscellaneous Phenomena (dates of).—Aurora, 0; halos: solar, 5, 18; lunar, 0; hail, 0; sleet, 13; fog, 14, 15; thunderstorms, 14; *frosts: light, 0; heavy, 0; killing, 0.

*Frosts are not recorded after the occurrence of "killing," except in Florida and along the immediate coast of the Gulf of Mexico.

DEWEY A. SEELEY.
Local Forecaster, Weather Bureau.

Meteorological observations for the month of March, 1911, at Agricultural College, East Lansing, Michigan.

Date.	Temperature. (Degrees Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. (In inches and hundredths.)	Character of day.	Snow on ground. (Inches.)
1	38	20	29	.01	Partly Cloudy.	0
2	34	26	30	.01	Cloudy	0
3	35	25	30	0	Partly Cloudy.	0
4	31	17	24	0	Partly Cloudy.	0
5	33	15	24	.05	Cloudy	0.3
6	37	23	30	0	Clear	0
7	34	21	28	0	Cloudy	0
8	38	16	27	0	Cloudy	0
9	53	32	42	.02	Cloudy	0
10	49	30	40	0	Clear	0
11	57	30	44	.08	Cloudy	0
12	50	25	38	.14	Cloudy	0
13	40	20	34	0	Clear	0
14	53	22	38	0	Clear	0
15	41	5	23	.01	Cloudy	0
16	24	7	16	0	Partly Cloudy.	0
17	42	16	29	0	Cloudy	0
18	38	23	30	0	Clear	0
19	47	28	38	.02	Partly Cloudy.	0
20	53	32	42	0	Clear	0
21	65	27	46	0	Clear	0
22	58	24	41	.14	Cloudy	0
23	35	20	28	0	Partly Cloudy.	0
24	40	14	27	0	Clear	0
25	59	26	42	0	Clear	0
26	55	44	50	.26	Cloudy	0
27	50	24	37	.11	Cloudy	0.1
28	30	23	26	0	Cloudy	0
29	36	27	32	.21	Cloudy	0.5
30	32	23	28	.06	Cloudy	0.5
31	34	14	24	.09	Partly Cloudy.	1.0
Mean	42.9	22.5	32.7	Total. 1.21		

Atmospheric Pressure. — (Reduced to sea level; inches and hundredths). — Mean, 30.02; highest, 30.63; date, 24; lowest, 29.32; date, 30.

Temperature.—Highest, 65; date, 21; lowest, 5; date, 15; greatest daily range, 38; date, 21; least daily range, 7; date, 28.

Precipitation.—Total this month, 1. 21; snowfall, 4.3; greatest precipitation in 24 hours, .37, date, 26 and 27; snow on the ground at end of month, 1.0.

Wind.—Prevailing direction, northwest; total movement, 6543 miles; average hourly velocity, 8.8; maximum velocity (for five minutes) 32 miles per hour, from northwest on 22.

Weather.—Number of days, clear, 9; partly cloudy, 7; cloudy, 15; on which .01 inch, or more, of precipitation occurred, 14.

Miscellaneous Phenomena (dates of).—Auroras, 0; halos: solar, 7, 9, 11, 19, 26; lunar, 8; hail, 27; sleet, 15; fog, 0; thunderstorms, 0. *frost: light, 0; heavy, 0; killing, 0;

*Frosts are not recorded after the occurrence of "killing," excepting in Florida and along the immediate coast of the Gulf of Mexico.

DEWEY A. SEELEY,
Local Forecaster, Weather Bureau.

Meteorological observations for the month of April, 1911, at Agricultural College, East Lansing, Michigan.

Date.	Temperature. (Degrees Fahrenheit.)			Precipitation. (In inches and hundredths.)	Character of day.	Percentage of possible sunshine.
	Maximum.	Minimum.	Mean.			
1	30	10	20	.03	Partly Cloudy.	72
2	34	18	26	0	Cloudy	52
3	39	23	31	0	Partly Cloudy.	62
4	45	30	38	.79	Cloudy	0
5	55	36	46	.02	Cloudy	0
6	45	30	38	.08	Cloudy	0
7	45	27	36	0	Clear	98
8	40	28	34	0	Cloudy	49
9	50	24	37	0	Clear	100
10	57	27	42	0	Clear	100
11	62	33	48	0	Clear	94
12	54	44	49	.19	Cloudy	0
13	58	49	54	.18	Cloudy	0
14	56	35	46	.17	Clear	97
15	43	28	36	0	Partly Cloudy.	79
16	50	24	37	0	Clear	100
17	54	26	40	0	Clear	100
18	68	38	53	.01	Cloudy	82
19	52	41	46	.37	Cloudy	0
20	61	36	48	0	Clear	99
21	55	37	46	.01	Cloudy	45
22	53	33	43	.04	Partly Cloudy.	77
23	52	30	41	.01	Partly Cloudy.	64
24	63	32	48	0	Clear	100
25	65	33	49	0	Clear	100
26	68	35	52	0	Clear	96
27	75	48	62	0	Cloudy	62
28	70	55	62	.04	Cloudy	40
29	71	56	64	.05	Cloudy	35
30	71	52	62	.12	Cloudy	37
Mean	54.7	33.9	44.3	Total. 2.11		61

Atmospheric Pressure.—(Reduced to sea level; inches and hundredths.)—Mean, 30.10; highest, 30.59; date, 10; lowest, 29.32; date, 5;

Temperature.—Highest, 75; date, 27; lowest, 10; date, 1; greatest daily range, 33; date, 26; least daily range, 9; date, 13.

Precipitation.—Total this month, 2.11; snowfall, .05; greatest precipitation in 24 hours, .79; date, 4; Snow on the ground at end of month, 0.

Wind.—Prevailing direction, southeast; total movement, 5461 miles; average hourly velocity, 7.6; maximum velocity (for five minutes) 28 miles per hour, from southwest on 5.

Weather.—Number of days, clear, 11; partly cloudy, 5; cloudy, 14; on which .01 inch, or more, of precipitation occurred, 15.

Miscellaneous Phenomena (dates of).—Auroras, 0; halos: solar, 10, 18, 26; lunar, 10, 11; hail, 0; sleet, 4; fog, 0; thunderstorms, 13; *frost: light, 25, 26; heavy, 24; killing, 16, 17, 23.

*Frosts are not recorded after the occurrence of "killing," except in Florida and along the immediate coast of the Gulf of Mexico.

DEWEY A. SEELEY,
Local Forecaster, Weather Bureau.

Meteorological observations for the month of May, 1911, at Agricultural College, East Lansing, Michigan.

Date.	Temperature. (Degrees Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. (In inches and hundredths.)	Character of day.	Percentage of possible sunshine.
1	62	31	46	.3	Cloudy	15
2	43	29	36	0	Cloudy	53
3	54	27	40	0	Partly cloudy.	73
4	56	29	42	0	Clear	100
5	64	30	47	0	Clear	100
6	71	35	53	0	Clear	1C0
7	75	42	58	0	Clear	100
8	78	47	62	0	Clear	83
9	78	57	68	0	Clear	76
10	78	56	67	.26	Partly cloudy.	55
11	76	56	66	0	Partly cloudy.	100
12	72	39	56	0	Clear	100
13	65	35	50	0	Clear	100
14	70	43	56	0	Cloudy	84
15	83	51	67	0	Cloudy	64
16	82	61	72	0	Cloudy	57
17	88	62	75	0	Partly cloudy.	89
18	89	67	78	0	Partly cloudy.	78
19	91	68	80	0	Clear	100
20	86	65	76	1.22	Partly cloudy.	66
21	84	65	74	0	Partly cloudy.	93
22	84	64	74	.11	Cloudy	51
23	78	55	66	.15	Partly cloudy.	85
24	75	53	64	0	Clear	92
25	88	53	70	0	Clear	100
26	90	65	78	0	Clear	100
27	93	64	78	0	Clear	100
28	87	63	75	.01	Clear	100
29	72	56	64	.01	Partly cloudy.	69
30	76	56	66	0	Partly cloudy.	71
31	73	51	62	.48	Partly cloudy.	46
Mean	76.2	50.8	63.5	Total. 2.67		

ATMOSPHERIC PRESSURE.—(Reduced to sea level; inches and hundredths).—Mean, 30.02; highest, 30.41; date, 6; lowest, 29.44; date, 1.

TEMPERATURE.—Highest, 93; date, 27; lowest, 27; date, 3; greatest daily range, 36; date, 6. least daily range, 14; date, 2.

PRECIPITATION.—Total this month, 2.67; snowfall, T; greatest precipitation in 24 hours, 1.22; date, 20; snow on the ground at end of month, 0.

WIND.—Prevailing direction, southwest; total movement, 4,330 miles; average hourly velocity, 5.8; maximum velocity (for five minutes) 31 miles per hour, from south, on 23.

WEATHER.—Number of days, clear, 14; partly cloudy, 11; cloudy, 6; on which .01 inch, or more, of precipitation occurred, 8.

MISCELLANEOUS PHENOMENA (dates of).—Auroras, 0; halos: solar, 14, 17, 25; lunar, 0; hail, 0; sleet, 0; fog, 0; thunderstorms, 1, 10, 20, 22, 23, 31, *frost: light, 6, 13; heavy, 2, 5; killing, 3, 4.

NOTE.—"T" indicates trace of precipitation.

*Frosts are not recorded after the occurrence of "killing," except in Florida and along the immediate coast of the Gulf of Mexico.

DEWEY A. SEELEY.
Local Forecaster, Weather Bureau.

Meteorological observations for the month of June, 1911, at Agricultural College, East Lansing, Michigan.

Date.	Temperature. (Degrees Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. (In inches and hundredths.)	Character of day.	Percentage of possible sunshine.
1	77	46	62	0	Clear	90
2	76	58	67	.04	Cloudy	57
3	73	59	66	.50	Cloudy	45
4	78	61	70	1.81	Partly cloudy	45
5	82	61	72	0	Partly cloudy	82
6	73	59	66	.05	Cloudy	47
7	63	54	58	0	Cloudy	6
8	74	53	64	0	Partly cloudy	65
9	87	59	73	0	Clear	86
10	93	71	82	0	Clear	96
11	80	57	68	.62	Partly cloudy	64
12	65	56	60	.16	Cloudy	18
13	63	50	56	0	Cloudy	8
14	75	46	60	0	Partly cloudy	86
15	79	49	64	0	Partly cloudy	100
16	78	58	68	0	Cloudy	60
17	70	55	62	.03	Cloudy	53
18	84	50	67	0	Clear	100
19	86	57	72	0	Clear	100
20	88	59	74	0	Clear	100
21	87	53	70	0	Clear	100
22	92	62	77	0	Clear	88
23	94	60	77	0	Clear	100
24	83	56	70	0	Partly cloudy	61
25	80	67	74	.44	Cloudy	40
26	87	70	78	.12	Cloudy	55
27	79	57	68	0	Partly cloudy	99
28	70	51	60	0	Partly cloudy	75
29	78	49	64	0	Clear	100
30	87	56	72	0	Clear	100
Mean	79.4	56.6	68.0	Total. 3.77		

ATMOSPHERIC PRESSURE.—(Reduced to sea level; inches and hundredths). Mean, 29.95; highest, 30.23; date, 29; lowest, 29.60; date, 12.

TEMPERATURE.—Highest, 94; date, 23; lowest, 46; date, 14; greatest daily range, 34, date, 21; least daily range, 9; date, 12.

PRECIPITATION.—Total this month, 3.77; snowfall, 0; greatest precipitation in 24 hours, 1.81; date, 4; snow on the ground at end of month, 0.

WIND.—Prevailing direction, southwest; total movement, 3359 miles; average hourly velocity, 4.7; maximum velocity (for five minutes), 32 miles per hour, from northeast, on 4.

WEATHER.—Number of days, clear, 11; partly cloudy, 9; cloudy, 10; on which .01 inch, or more, of precipitation occurred, 9.

MISCELLANEOUS PHENOMENA (dates of).—Auroras, 0; halos: solar, 4, 26; lunar, 0; hail, 4; sleet, 0; fog, 6, 8; thunderstorms, 3; 4, 11, 24, 25, 26; *frost: light, 0; heavy, 0; killing, 0.

*Frosts are not recorded after the occurrence of "killing," except in Florida and along the immediate coast of the Gulf of Mexico.

DEWEY A. SEELEY,
Local Forecaster, Weather Bureau.

Meteorological observations for the month of July, 1911, at Agricultural College, East Lansing, Michigan.

Date.	Temperature. (Degrees Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. (In inches and hundredths.)	Character of day.	Percent of sunshine.
1	94	63	78	0	Clear	95
2	96	69	82	0	Clear	100
3	98	70	84	0	Clear	100
4	98	68	83	0	Clear	100
5	99	75	87	0	Clear	100
6	84	66	75	.72	Cloudy	47
7	86	61	74	0	Clear	98
8	92	64	78	0	Clear	100
9	92	72	82	0	Clear	98
10	88	70	79	.01	Partly cloudy	82
11	91	70	80	0	Clear	82
12	79	56	68	0	Clear	100
13	82	53	68	0	Clear	85
14	82	50	66	0	Clear	100
15	83	52	68	.25	Partly cloudy	67
16	73	59	66	.35	Cloudy	36
17	74	51	62	0	Clear	100
18	80	48	64	0	Partly cloudy	85
19	79	59	69	.11	Cloudy	42
20	80	54	67	0	Clear	100
21	79	53	66	0	Clear	100
22	81	51	66	0	Clear	100
23	76	51	64	.10	Cloudy	28
24	68	53	60	.10	Cloudy	55
25	68	48	58	.01	Partly cloudy	84
26	76	44	60	0	Partly cloudy	93
27	79	47	63	0	Clear	98
28	84	58	71	0	Partly cloudy	70
29	83	64	74	0	Partly cloudy	81
30	87	60	74	0	Clear	100
31	90	61	76	0	Clear	90
Mean	83.9	58.7	71.3	Total. 1.65		

Atmospheric Pressure.—(Reduced to sea level; inches and hundredths).—Mean, 29.99; highest, 30.23; date, 27; lowest, 29.56; date, 24.

Temperature.—Highest, 99; date, 5; lowest, 44; date, 26; greatest daily range, 32; date, 26; least daily range, 14; date, 16.

Precipitation.—Total this month, 1.65; snowfall, 0; greatest precipitation in 24 hours, .72; date, 6; snow on the ground at end of month, 0.

Wind.—Prevailing direction, southwest; total movement, 3882 miles; average hourly velocity, 5.2; maximum velocity, (for five minutes), 28 miles per hour, from northwest, on 24.

Weather.—Number of days, clear, 19; partly cloudy, 7; cloudy, 5; on which .01 inch, or more, of precipitation occurred, 8.

Miscellaneous Phenomena (dates of).—Auroras, 0; halos: solar, 0; lunar, 0; hail, 24; sleet, 0; fog, 0; thunderstorms, 6, 15, 16, 19; *frost: light, 0; heavy, 0; killing, 0.

*Frosts are not recorded after the occurrence of "killing," except in Florida and along the immediate coast of the Gulf of Mexico.

DEWEY A. SEELEY,
Local Forecaster, Weather Bureau.

Meteorological observations for the month of August, 1911, at Agricultural College, East Lansing, Michigan.

Date.	Temperature. (Degrees Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. (In inches and hundredths.)	Character of day.	Percent of sunshine.
1	80	66	73	.30	Partly cloudy.	75
2	81	61	71	.04	Partly cloudy.	79
3	84	58	71	0	Partly cloudy.	76
4	86	62	74	0	Partly cloudy.	87
5	91	63	77	0	Partly cloudy.	79
6	93	61	77	0	Clear	100
7	89	66	78	0	Partly cloudy.	97
8	83	60	72	0	Clear	100
9	92	54	73	0	Clear	100
10	92	60	76	0	Cloudy	57
11	72	60	66	.14	Cloudy	35
12	76	58	67	0	Cloudy	38
13	75	61	68	.01	Cloudy	6
14	86	64	75	.04	Cloudy	64
15	86	66	76	.47	Partly cloudy.	79
16	87	64	76	.18	Partly cloudy.	68
17	84	62	73	0	Clear	88
18	77	54	66	0	Clear	79
19	73	48	60	0	Clear	96
20	77	46	62	0	Clear	99
21	81	51	66	0	Clear	99
22	80	56	68	.20	Cloudy	38
23	72	52	62	0	Partly cloudy.	78
24	60	53	56	.10	Cloudy	8
25	72	50	61	0	Partly cloudy.	84
26	79	46	62	0	Clear	100
27	82	60	71	0	Partly cloudy.	79
28	74	48	61	0	Partly cloudy.	55
29	68	42	55	0	Clear	100
30	73	40	56	0	Clear	100
31	78	49	64	0	Partly cloudy.	85
Mean	80.1	56.2	68.2	Total. 1.48		75

Atmospheric Pressure.—(Reduced to sea level; inches and hundredths).—Mean, 30.02; highest, 30.29; date, 30; lowest, 29.77; date, 7.

Temperature.—Highest, 93; date, 6; lowest, 40; date, 30; greatest daily range, 38; date, 9; least daily range,7; date, 24.

Precipitation—Total this month, 1.48; snowfall, 0; greatest precipitation in 24 hours, .51; date, 14 and 15; snow on the ground at end of month, 0.

Wind.—Prevailing direction, south; total movement, 3188 miles; average hourly velocity, 4.3; maximum velocity (for five minutes), 21 miles per hour, from north, on 10.

Weather.—Number of days, clear, 11; partly cloudy, 13; cloudy, 7; on which .01 inch, or more, of precipitation occurred, 9.

Miscellaneous Phenomena (dates of).—Auroras, 0; halos: solar, 0; lunar, 0; hail, 0; sleet, 0; fog, 17; thunderstorms, 10, 11, 14, 15 and 16. *frost: light, 30; heavy, 0; killing, 0.

*Frosts are not recorded after the occurrence of "killing," except in Florida and along the immediate coast of the Gulf of Mexico.

DEWEY A. SEELEY,
Local Forecaster, Weather Bureau.

Meteorological observations for the month of September, 1911, at Agricultural College, East Lansing, Michigan.

Date.	Temperature. (Degrees Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. (In inches and hundredths.)	Character of day.	Percentage of possible sunshine.
1	89	55	72	0	Clear	100
2	85	53	69	.02	Partly cloudy.	80
3	74	44	59	0	Clear	100
4	79	45	62	0	Clear	100
5	74	57	66	.49	Cloudy	28
6	65	56	60	0	Cloudy	2
7	76	55	66	0	Cloudy	26
8	71	55	63	0	Cloudy	12
9	79	55	67	0	Clear	72
10	76	53	64	.01	Cloudy	38
11	81	57	69	.36	Partly cloudy.	72
12	64	46	55	.01	Clear	87
13	66	45	56	0	Clear	85
14	71	44	58	.55	Cloudy	27
15	79	57	68	0	Partly cloudy.	62
16	82	51	66	0	Clear	100
17	85	50	68	0	Clear	100
18	83	62	72	.54	Cloudy	49
19	72	45	58	0	Clear	85
20	72	42	57	0	Partly cloudy	85
21	60	53	56	.10	Cloudy	0
22	72	48	60	0	Clear	80
23	78	48	63	0	Clear	100
24	63	55	59	.42	Cloudy	0
25	62	54	58	0	Cloudy	4
26	63	49	56	0	Partly cloudy.	64
27	74	46	60	1.08	Partly cloudy.	44
28	63	38	50	1.22	Partly cloudy.	58
29	67	47	57	.24	Cloudy	5
30	56	45	50	.01	Partly cloudy.	53
Mean	72.7	50.3	61.5	Total. 5.05		58

Atmospheric Pressure.—(Reduced to sea level; inches and hundredths).—Mean, 30.06; highest, 30.36; date, 22; lowest, 29.72; date, 11.

Temperature.—Highest, 89; date, 1; lowest, 38; date, 28; greatest daily range, 35; date, 17; least daily range, 7; date, 21.

Precipitation.—Total this month, 5.05; snowfall, 0; greatest precipitation in 24 hours, 1.46; date, 28 and 29; snow on the ground at end of month, 0.

Wind.—Prevailing direction, southeast; total movement, 3460 miles; average hourly velocity, 4.8; maximum velocity (for five minutes), 20 miles per hour, from northwest, on 11.

Weather.—Number of days, clear, 11; partly cloudy, 8; cloudy, 11; on which .01 inch, or more, of precipitation occurred, 13.

Miscellaneous Phenomena (dates of).—Auroras, 0; halos: solar, 28; lunar, 11; hail, 0; sleet, 0; fog, 7, 8, 10, 11, 22; thunderstorms, 2, 5, 11, 14, 18, 24, 27, 28; *frosts: light, 0; heavy, 0; killing, 0.

*Frosts are not recorded after the occurrence of "killing," except in Florida and along the immediate coast of the Gulf of Mexico.

DEWEY A. SEELEY,
Local Forecaster, Weather Bureau.

Meteorological observations for the month of October, 1911, at Agricultural College, East Lansing, Michigan.

Date.	Temperature. (Degrees Fahrenheit). Maximum.	Minimum.	Mean.	Precipitation. (In inches and hundredths.)	Character of day.	Percentage of possible sunshine.
1	53	50	52	1.91	Cloudy	0
2	61	44	52	0	Partly cloudy.	70
3	69	42	56	.72	Cloudy	3
4	69	44	56	0	Partly cloudy.	62
5	50	35	42	0	Cloudy	55
6	54	44	49	.75	Cloudy	0
7	52	34	43	0	Partly cloudy.	61
8	61	31	46	0	Clear	100
9	62	34	48	0	Cloudy	54
10	56	49	52	.13	Cloudy	0
11	62	44	53	0	Cloudy	24
12	67	44	56	0	Partly cloudy.	65
13	61	37	49	0	Partly cloudy	89
14	59	43	51	0	Cloudy	6
15	66	49	58	0	Partly cloudy.	42
16	71	48	60	.16	Partly cloudy.	58
17	64	44	54	.45	Cloudy	0
18	66	40	53	0	Clear	100
19	66	44	55	0	Clear	84
20	52	45	48	.08	Cloudy	0
21	50	44	47	.26	Cloudy	0
22	48	37	42	.17	Cloudy	1
23	45	39	42	.01	Cloudy	1
24	53	36	44	0	Clear	87
25	60	41	50	0	Clear	74
26	50	32	41	.05	Partly cloudy.	50
27	42	26	34	.02	Cloudy	39
28	47	26	36	0	Partly cloudy.	60
29	51	29	40	0	Clear	100
30	46	32	39	.15	Cloudy	0
31	42	36	39	.14	Cloudy	0
Mean	56.6	39.5	48.0	Total. 5.00		42

Atmospheric Pressure.—(Reduced to sea level; inches and hundredths).—Mean, 30.08; highest, 30.39; date, 24; lowest, 29.62; date, 17.

Temperature.—Highest, 71; date, 16; lowest, 26; date, 28; greatest daily range, 30; date, 8; least daily range, 3; date, 1.

Precipitation.—Total this month, 5.00; snowfall, 0.3; greatest precipitation in 24 hours, 1.91; date, 1; snow on the ground at end of month, 0.

Wind.—Prevailing direction, east; total movement, 4143 miles; average hourly velocity, 5.6; maximum velocity (for five minutes), 25 miles per hour, from west, on 4.

Weather.—Number of days, clear, 6; partly cloudy, 9; cloudy, 16; on which .01 inch, or more, of precipitation occurred, 14.

Miscellaneous Phenomena (dates of).—Auroras, 0; halos: solar, 3, 5, 13; lunar, 0; hail, 0; sleet, 23; fog, 11, 12, 15; thunderstorms, 3, 16; *frost: light, 5; heavy, 0; killing, 8.

*Frosts are not recorded after the occurrence of "killing," except in Florida and along the immediate coast of the Gulf of Mexico.

DEWEY A. SEELEY,
Local Forecaster, Weather Bureau.

Meteorological observations for the month of November, 1911, at Agricultural College, East Lansing, Michigan.

Date.	Temperature. (Degrees Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. (In inches and hundredths.)	Character of day.	Snow on ground at 7 p. m.
1	41	26	34	.03	Cloudy	0
2	34	21	28	0	Partly cloudy.	0
3	43	21	32	0	Partly cloudy.	0
4	41	29	35	0	Cloudy	0
5	42	36	42	0	Cloudy	0
6	52	40	46	.40	Cloudy	0
7	44	39	42	.03	Cloudy	0
8	48	30	39	0	Clear	0
9	49	32	40	.16	Cloudy	0
10	60	45	52	.02	Partly cloudy.	0
11	68	54	61	.65	Cloudy	0
12	54	14	34	.55	Cloudy	0.8
13	22	12	17	.05	Cloudy	1.0
14	28	22	25	.11	Cloudy	2.0
15	35	18	26	.01	Cloudy	1.0
16	30	12	21	0	Partly cloudy.	0
17	48	28	38	.76	Cloudy	0
18	36	26	31	.05	Cloudy	0.5
19	33	26	30	0	Cloudy	0.0
20	33	25	29	.05	Cloudy	0.5
21	35	26	30	.01	Cloudy	0
22	37	23	30	0	Cloudy	0
23	35	29	32	0	Cloudy	0
24	30	26	28	.01	Cloudy	0.2
25	35	24	30	0	Cloudy	0
26	43	29	36	0	Partly cloudy.	0
27	50	34	42	0	Partly cloudy.	0
28	43	23	33	.51	Cloudy	0.1
29	32	19	26	0	Clear	0
30	32	19	26	0	Cloudy	0
Mean	40.6	26.9	33.8	Total. 3.40		

ATMOSPHERIC PRESSURE.—(Reduced to sea level; inches and hundredths).—Mean, 29.97; highest, 30.65; date, 2; lowest, 29.25; date, 17.

TEMPERATURE.—Highest, 68; date, 11; lowest, 12; date, 16; greatest daily range, 40; date, 12; least daily range, 4; date, 24.

PRECIPITATION.—Total this month, 3.40; snowfall, 8.2; greatest precipitation in 24 hours, 1.14; date, 11 and 12; snow on the ground at end of month, 0.

WIND.—Prevailing direction, southwest; total movement, 6,423 miles; average hourly velocity, 8.9; maximum velocity (for five minutes), 31 miles per hour, from south, on 11.

WEATHER.—Number of days, clear, 2; partly cloudy, 6; cloudy, 22; on which .01 inch, or more, of precipitation occurred, 16.

MISCELLANEOUS PHENOMENA (dates of).—Auroras, 0; halos: solar, 16; lunar, 3, 5; hail, 0; sleet, 7, 17; fog, 0; thunderstorms, 11.

DEWEY A. SEELEY,
Local Forecaster, Weather Bureau.

Meteorological observations for the month of December, 1911, at Agricultural College, East Lansing, Michigan.

Date.	Temperature. (Degrees Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. (In inches and hundredths.)	Character of day.	Depth of snow on ground at 7 p. m.
1	34	26	30	0	Cloudy	0
2	33	26	30	.02	Cloudy	0.2
3	26	8	17	.10	Cloudy	1.7
4	30	6	18	0	Cloudy	1.0
5	40	23	32	0	Clear	0.3
6	46	25	36	0	Clear	0
7	43	34	38	.01	Cloudy	0
8	46	34	40	.18	Cloudy	0
9	50	46	48	.05	Cloudy	0
10	57	46	52	.08	Cloudy	0
11	46	36	41	.01	Cloudy	0
12	38	32	35	0	Cloudy	0
13	40	25	32	0	Clear	0
14	34	24	29	0	Cloudy	0
15	34	27	30	0	Cloudy	0
16	33	28	30	.25	Cloudy	3.5
17	32	27	30	.01	Cloudy	3.0
18	33	26	30	0	Cloudy	2.4
19	29	10	20	0	Clear	2.2
20	33	15	24	0	Partly cloudy	1.8
21	38	32	35	.11	Cloudy	0.2
22	42	34	38	0	Cloudy	0
23	34	29	32	0	Cloudy	0
24	43	27	35	0	Clear	0
25	40	25	32	0	Partly cloudy	0
26	40	24	32	.12	Cloudy	0
27	37	11	24	.06	Cloudy	0.8
28	22	11	16	0	Clear	0.8
29	33	11	22	0	Clear	0.4
30	32	30	31	.44	Cloudy	1.4
31	36	16	26	.14	Cloudy	1.0
Mean	37.2	25.0	31.1	Total. 1.58		

Atmospheric Pressure.—(Reduced to sea level; inches and hundredths).—Mean, 30.11; highest, 30.63; date, 19; lowest, 29.39; date, 26.

Temperature.—Highest, 57; date, 10; lowest, 6; date, 4; greatest daily range, 26; date, 27; least daily range, 2; date, 30.

Precipitation.—Total this month, 1.58; snowfall, 10.1; greatest precipitation in 24 hours, 0.55; date, 30 and 31; snow on the ground at end of month, 1.0.

Wind.—Prevailing direction, southwest; total movement, 5,077 miles; average hourly velocity, 5.3; maximum velocity (for five minutes), 30 miles per hour, from southwest, on 27.

Weather.—Number of days, clear, 7; partly cloudy, 2; cloudy, 22; on which .01 inch, or more, of precipitation occurred, 14.

Miscellaneous Phenomena (dates of).—Auroras, 0; halos: solar, 20; lunar, 12, 28; hail, 0; sleet, 0; fog, 19; thunderstorms, 0.

DEWEY A. SEELEY,
Local Forecaster, Weather Bureau.

Meteorological observations for the month of January, 1912, at Agricultural College, East Lansing, Michigan.

Date.	Temperature. (Degrees Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. (In inches and hundredths.)	Character of day.	Snow on ground. (Inches.)
1	19	16	18	0	Cloudy	0.6
2	21	4	12	.01	Cloudy	0.6
3	18	2	10	0	Partly cloudy	0.5
4	15	0	8	.03	Cloudy	0.6
5	6	-4	1	.01	Partly cloudy	0.8
6	4	-6	-1	.02	Cloudy	0.6
7	4	-5	0	0	Partly cloudy	0.6
8	14	-1	6	.31	Cloudy	4.3
9	7	-3	2	.02	Partly cloudy	4.5
10	6	-6	0	0	Partly cloudy	4.4
11	8	-5	2	0	Partly cloudy	4.4
12	7	-14	-4	0	Clear	4.2
13	10	-17	-4	0	Partly cloudy	4.1
14	16	6	11	.05	Cloudy	4.1
15	12	-6	3	0	Clear	4.7
16	17	-5	6	0	Partly cloudy	4.5
17	29	13	21	0	Cloudy	4.3
18	35	16	26	.11	Cloudy	5.0
19	16	1	8	0	Cloudy	5.0
20	18	1	10	.03	Cloudy	5.5
21	23	7	15	0	Cloudy	5.5
22	28	16	22	.08	Cloudy	5.5
23	27	12	20	0	Cloudy	6.3
24	15	7	11	0	Cloudy	6.3
25	12	8	10	.01	Cloudy	6.3
26	17	8	12	.08	Cloudy	7.5
27	17	-11	3	0	Clear	7.4
28	19	-12	4	0	Cloudy	7.3
29	23	19	21	0	Cloudy	7.2
30	25	14	20	.04	Cloudy	7.5
31	27	3	15	0	Clear	6.8
Mean	16.6	1.9	9.2	Total. 0.80		

Atmospheric Pressure.—(Reduced to sea level; inches and hundredths).—Mean, 30.03; highest, 30.62; date, 12; lowest, 29.45; date, 8.

Temperature.—Highest, 35; date, 18; lowest, -17; date, 13; greatest daily range, 31; date, 28; least daily range, 3; date, 1.

Precipitation.—Total this month, 0.80; snowfall, 10.1; greatest precipitation in 24 hours, 0.31; date, 8; snow on the ground at end of month, 6.8.

Wind.—Prevailing direction, west; total movement, 3639 miles; average hourly velocity, 4.9; maximum velocity (for five minutes), 18 miles per hour, from southwest, on 1.

Weather.—Number of days, clear, 4; partly cloudy, 8; cloudy, 19; on which .01 inch, or more, of precipitation occurred, 13.

Miscellaneous Phenomena (dates of).—Auroras, 0; halos: solar, 3-5, 6, 11, 13; lunar, 3, 4, 5, 6; hail, 0; sleet, 28; fog, 0; thunderstorms, 0.

DEWEY A. SEELEY,
Local Forecaster, Weather Bureau.

Meteorological observations for the month of February, 1912, at Agricultural College, East Lansing, Michigan.

Date.	Temperature. (Degrees Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. (In inches and hundredths.)	Character of day.	Snow on ground. (Inches.)
1	29	2	16	.06	Cloudy	7.0
2	16	1	8	.02	Partly cloudy.	7.5
3	10	−18	−4	0	Clear	7.3
4	4	−8	−2	.01	Partly cloudy.	7.2
5	15	2	8	0	Partly cloudy.	6.9
6	22	13	18	0	Cloudy	6.5
7	25	4	14	.02	Cloudy	6.8
8	12	2	7	.01	Partly cloudy.	6.5
9	7	−18	−6	0	Clear	6.4
10	5	−25	−10	0	Partly cloudy.	6.2
11	15	3	9	.14	Cloudy	8.2
12	16	−12	2	0	Clear	8.0
13	19	−18	0	0	Clear	7.7
14	28	13	20	.01	Cloudy	7.8
15	39	22	30	0	Partly cloudy.	6.2
16	33	25	29	0	Cloudy	5.0
17	38	26	32	0	Partly cloudy.	4.5
18	43	29	36	.01	Cloudy	4.0
19	40	29	34	0	Partly cloudy.	3.0
20	32	21	26	0	Partly cloudy.	2.0
21	21	9	15	1.05	Cloudy	11.2
22	19	8	14	.01	Partly cloudy.	12.5
23	36	13	24	.04	Partly cloudy.	11.0
24	46	35	40	0	Cloudy	7.0
25	36	27	32	.08	Cloudy	6.0
26	34	14	24	.50	Cloudy	10.0
27	23	12	18	.01	Partly cloudy.	9.9
28	24	0	12	.06	Cloudy	10.0
29	23	−1	11	.01	Cloudy	9.5
Mean	24.5	7.2	15.8	Total. 2.04		

Atmospheric Pressure.—(Reduced to sea level; inches and hundredths.)—Mean, 29.99; highest, 30.58; date, 13; lowest, 29.18; date, 21.

Temperature.—Highest, 46; date, 24; lowest, −25; date, 10; greatest daily range, 37; date, 13; least daily range, 8; date, 16.

Precipitation.—Total this month, 2.04; snowfall, 24.5; greatest precipitation in 24 hours, 1.05; date, 21; snow on the ground at end of month, 9.5;

Wind.—Prevailing direction, southwest; total movement, 4386 miles; average hourly velocity, 6.3; maximum velocity (for five minutes), 29 miles per hour, from northeast, on 21.

Weather.—Number of days, clear, 4; partly cloudy, 12; cloudy, 13; on which .01 inch, or more, of precipitation occurred, 16.

Miscellaneous Phenomena (dates of).—Auroras, 0; halos: solar, 3, 13, 19, 20; lunar, 22; hail, 0; sleet, 26; fog, 0; thunderstorms, 0.

DEWEY A. SEELEY,
Local Forecaster, Weather Bureau.

Meteorological observations for the month of March, 1912, at Agricultural College, East Lansing, Michigan.

Date.	Temperature. (Degrees Fahrenheit.)			Precipitation. (In inches and hundredths.)	Character of day.	Snow on ground at 7 p. m. (Inches.)
	Maximum.	Minimum.	Mean.			
1	19	-2	8	0	Partly cloudy.	9.3
2	15	-5	5	0	Partly cloudy.	9.0
3	18	2	10	0	Partly cloudy.	8.5
4	21	-2	10	0	Partly cloudy.	8.0
5	21	-2	10	0	Clear	7.0
6	27	-4	12	0	Clear	6.0
7	33	5	19	.02	Partly cloudy.	5.5
8	32	15	24	0	Cloudy	5.5
9	23	4	14	0	Clear	5.0
10	30	7	18	0	Clear	4.0
11	28	6	17	.17	Cloudy	5.0
12	34	18	26	.07	Partly cloudy.	5.0
13	34	8	21	0	Clear	4.0
14	36	17	20	.15	Cloudy	3.5
15	30	8	19	.74	Cloudy	14.0
16	36	-1	18	0	Clear	10.0
17	47	23	35	0	Cloudy	5.0
18	44	32	38	0	Clear	3.0
19	50	26	38	0	Partly cloudy.	1.0
20	26	11	18	.33	Cloudy	1.0
21	27	16	22	.16	Cloudy	4.5
22	29	11	20	0	Clear	4.0
23	35	14	24	0	Cloudy	3.5
24	32	16	24	0	Partly cloudy.	3.0
25	33	9	29	0	Partly cloudy.	2.0
26	40	26	33	0	Partly cloudy.	1.0
27	42	21	32	0	Partly cloudy.	0.5
28	39	26	32	0	Cloudy	0.3
29	37	24	30	0	Partly cloudy	0.2
30	43	19	31	0	Clear	0
31	46	31	38	.28	Cloudy	0
Mean	32.5	12.2	22.4	Total. 1.92		

Atmospheric Pressure.—(Reduced to sea level; inches and hundredths).—Mean, 30.17; highest, 30.72; date, 5; lowest, 29.55; date, 29.

Temperature.—Highest, 50; date, 19; lowest, -5; date, 2; greatest daily range, 37; date, 10; least daily range, 11; date, 21.

Precipitation.—Total this month, 1.92; snowfall, 20.7; greatest precipitation in 24 hours, .89; date, 14 and 15; snow on the ground at end of month, 0.

Wind.—Prevailing direction, northeast; total movement, 4,906 miles; average hourly velocity, 6.6; maximum velocity (for five minutes), 22 miles per hour, from northeast, on 24.

Weather.—Number of days, clear, 9; partly cloudy, 12; cloudy, 10; on which .01 inch, or more, of precipitation occurred, 8.

Miscellaneous Phenomena (dates of).—Auroras, 0; halos: solar, 2, 3, 7, 16, 17, 19, 23, 25, 27, 31; lunar, 2, 25, hail, 0; sleet, 31; fog, 29; thunderstorms, 31.

DEWEY A. SEELEY,
Local Forecaster, Weather Bureau.

Meteorological observations for the month of April, [illegible], at Agricultural College, East Lansing, Michigan.

Date.	Temperature—Degrees Fahrenheit. Maximum.	Minimum.	Mean.	Precipitation, in inches and hundredths.	Character of day.	Percentage of possible sunshine.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Cloudy	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Cloudy	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Clear	100
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Clear	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Partly cloudy	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Partly cloudy	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Cloudy	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Cloudy	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Clear	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Clear	100
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Clear	100
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Cloudy	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Cloudy	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Partly cloudy	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Clear	100
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Cloudy	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Cloudy	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Cloudy	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Clear	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Clear	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Partly cloudy	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Cloudy	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Partly cloudy	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Clear	100
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Partly cloudy	100
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Partly cloudy	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Clear	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Cloudy	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Cloudy	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Clear	100
Mean.	[illegible]	[illegible]	[illegible]	Total. [illegible]		[illegible]

[illegible]

DEWEY A. SEELEY,
Local Forecaster, Weather Bureau.

Meteorological observations for the month of May, 19[illegible], at Agricultural College, East Lansing, Michigan.

Date.	Temperature, Degrees Fahrenheit. Maximum.	Minimum.	Mean.	Precipitation. In inches and hundredths.	Character of day.	Percentage of possible sunshine.
1	[illegible]	[illegible]	[illegible]	[illegible]	Cloudy	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	Partly cloudy	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	Cloudy	100
4	[illegible]	[illegible]	[illegible]	[illegible]	Partly cloudy	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	Cloudy	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	Partly cloudy	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	Partly cloudy	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	Clear	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	Clear	100
10	[illegible]	[illegible]	[illegible]	[illegible]	Clear	100
11	[illegible]	[illegible]	[illegible]	[illegible]	Cloudy	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	Cloudy	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	Partly cloudy	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	Partly cloudy	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	Cloudy	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	Cloudy	[illegible]
17	[illegible]	[illegible]	[illegible]	[illegible]	Clear	[illegible]
18	[illegible]	[illegible]	[illegible]	[illegible]	Partly cloudy	[illegible]
19	[illegible]	[illegible]	[illegible]	[illegible]	Cloudy	[illegible]
20	[illegible]	[illegible]	[illegible]	[illegible]	Cloudy	[illegible]
21	[illegible]	[illegible]	[illegible]	[illegible]	Cloudy	[illegible]
22	[illegible]	[illegible]	[illegible]	[illegible]	Clear	[illegible]
23	[illegible]	[illegible]	[illegible]	[illegible]	Partly cloudy	[illegible]
24	[illegible]	[illegible]	[illegible]	[illegible]	Clear	[illegible]
25	[illegible]	[illegible]	[illegible]	[illegible]	Clear	[illegible]
26	[illegible]	[illegible]	[illegible]	[illegible]	Clear	[illegible]
27	[illegible]	[illegible]	[illegible]	[illegible]	Partly cloudy	[illegible]
28	[illegible]	[illegible]	[illegible]	[illegible]	Cloudy	[illegible]
29	[illegible]	[illegible]	[illegible]	[illegible]	Cloudy	[illegible]
30	[illegible]	[illegible]	[illegible]	[illegible]	Clear	100
31	[illegible]	[illegible]	[illegible]	[illegible]	Clear	100
Mean	[illegible]	[illegible]	[illegible]	Total. [illegible]		[illegible]

Atmospheric pressure.—Reduced to sea level; inches and hundredths.—Mean, [illegible]; highest, [illegible]; date, [illegible]; lowest, [illegible]; date, [illegible].

Temperature.—Highest, [illegible]; date, [illegible]; lowest, [illegible]; date, [illegible]; greatest daily range, [illegible]; date, [illegible]; least daily range, [illegible]; date, [illegible].

Precipitation.—Total this month, [illegible]; snowfall, [illegible]; greatest precipitation in 24 hours, [illegible]; date, [illegible]; snow on the ground at end of month, [illegible].

Wind.—Prevailing direction, [illegible]; total movement, [illegible] miles; average hourly velocity, [illegible]; maximum velocity (for five minutes), [illegible] miles per hour, from [illegible], on [illegible].

Weather.—Number of days clear, [illegible]; partly cloudy, [illegible]; cloudy, [illegible]; on which [illegible] inch or more of precipitation occurred, [illegible].

Miscellaneous Phenomena (dates of).—[illegible]

*Frosts are not recorded after the occurrence of "killing," except in Florida and along the immediate coast of the Gulf of Mexico.

DEWEY A. SEELEY,
Local Forecaster, Weather Bureau.

Meteorological observations for the month of June, 1912, at Agricultural College, East Lansing, Michigan.

Date.	Temperature. (Degrees Fahrenheit.) Maximum.	Minimum.	Mean.	Precipitation. (In inches and hundredths.)	Character of day.	Percentage of possible sunshine.
1	81	55	68	0	Clear	100
2	68	55	62	.03	Cloudy	43
3	80	54	67	.57	Clear	84
4	67	44	56	0	Clear	87
5	69	43	56	0	Partly cloudy	89
6	66	47	56	0	Clear	82
7	62	43	52	0	Clear	100
8	71	40	56	.01	Clear	92
9	73	43	58	0	Clear	100
10	75	43	59	0	Clear	100
11	80	50	65	0	Partly cloudy	86
12	74	52	63	0	Partly cloudy	76
13	70	46	58	0	Partly cloudy	86
14	66	50	58	.08	Cloudy	22
15	82	64	73	.15	Cloudy	45
16	79	54	66	.01	Partly cloudy	79
17	69	51	60	0	Clear	100
18	69	45	57	0	Partly cloudy	88
19	72	53	62	0	Cloudy	66
20	75	52	64	0	Partly cloudy	82
21	73	48	60	0	Cloudy	100
22	76	47	62	0	Clear	100
23	81	50	66	0	Clear	100
24	80	54	67	0	Cloudy	70
25	85	56	70	0	Clear	100
26	81	59	70	0	Partly cloudy	99
27	80	57	68	0	Partly cloudy	86
28	89	57	73	.12	Partly cloudy	78
29	89	63	76	0	Partly cloudy	84
30	77	52	64	0	Clear	100
Mean	75.3	50.9	63.1	Total. 0.97		84

ATMOSPHERIC PRESSURE.—(Reduced to sea level; inches and hundredths).—Mean, 30.03; highest, 30.46; date, 10; lowest, 29.49; date, 15.

TEMPERATURE.—Highest, 89; date, 28; lowest, 40; date, 8; greatest daily range, 32; date, 28; least daily range, 13; date, 2.

PRECIPITATION.—Total this month, 0.97; snowfall, 0; greatest precipitation in 24 hours, .57; date, 3; snow on the ground at end of month, 0.

WIND.—Prevailing direction, southwest; total movement, 3696 miles; average hourly velocity, 5.1; maximum velocity (for, five minutes), 22 miles per hour, from northwest, on 4.

WEATHER.—Number of days, clear, 13; partly cloudy, 11; cloudy, 6; on which .01 inch, or more, of precipitation occurred, 7.

MISCELLANEOUS PHENOMENA (dates of).—Auroras, 0; halos: solar, 15, 27, 29; lunar, 0; hail, 0; sleet, 0; fog, 0; thunderstorms, 3, 8, 15, 28, 29; *frost: light, 0; heavy, 0; killing, 0;

*Frosts are not recorded after the occurrence of "killing," except in Florida and along the immediate coast of the Gulf of Mexico.

DEWEY A. SEELEY,
Local Forecaster, Weather Bureau.

REPORT OF THE MICHIGAN WEATHER SERVICE.

FOR THE FISCAL YEAR ENDING JUNE 30, 1912.

To the State Board of Agriculture:

Gentlemen—The operation of the Weather Service continues along the general lines of endeavor that have prevailed for some years past and also during the past year, to a general compilation of the records of the past 25 years. The principal work of this service is to collect in detail and more than the United States Weather Service would do, climatic data of Michigan and to co-operate with the United States in the distribution of the daily forecast and warnings.

March, 1912, marked the rounding out of a quarter of a century of general observation work by the Michigan Weather Service. Previous to that time most of the records made in Michigan had been from places located on the immediate lake shores and at stations established by the United States Weather Bureau. Since 1887 a large number of inland stations have been maintained and from the records of all of these stations a fairly good climatology has resulted.

During the past six months we have compiled this 25 year data both by text and charts into a chapter which will be published with the Soil of Michigan by the Geological Survey.

A 25-year record furnishes a fairly good set of normal temperatures and like precipitation data and Michigan is quite fortunate in having this data in such detail that the Weather Bureau can apply it to practically every county in the state.

The value of the records is becoming more generally known by the public and the calls for information are varied and constantly increasing.

This distribution of the daily weather forecasts is constantly increasing as the telephone service grows. The rural telephone is becoming more common and it enables the farmer to use the weather forecasts more generally than ever before. All of the principal telephone companies of the state co-operate with the Weather Bureau in forecast dissemination and a very complete system for distributing them is now in vogue.

Monthly and annual reports have been published as heretofore covering the daily observations taken by over a hundred voluntary observers.

C. F. SCHNEIDER,
Section Director.

Dated at Grand Rapids, Michigan, June 30, 1912.

REPORT OF STATE INSPECTOR OF NURSERIES AND ORCHARDS.

To the State Board of Agriculture:

Gentlemen—During the past year this department has been called upon for more than the usual amount of work. This has been due to a number of causes, among which are: First, the establishment of several new nurseries; (2) the appearance of peach yellows, little peach and the San Jose scale in new localities; (3) the unusual virulence of these diseases and the rapid development and spread of the scale in regions already infested; (4) increased interest in fruit culture and a more general desire to control the more dangerous insects and diseases, and (5) a great increase in the number of importations of nursery stock from Europe which have required inspection in order to prevent the introduction of the brown-tail and gypsy moths and other dangerous insects and diseases.

INSPECTION OF NURSERIES.

For the first time the number of licensed nurseries in Michigan exceeds 100. The stock grown by all of these has been inspected at least once during the season. Besides this, fully as many plantations of small fruit plants have been inspected; as, although the growers are allowed to sell surplus plants without taking out a license, the plants cannot be handled by the nurseries, to whom they are generally sold, until they have been inspected.

The improvement in the condition of several of the Michigan nurseries referred to last year has continued. This has been brought about in several ways. The trouble is for the most part due to the San Jose scale spreading to nursery stock from neighboring infested orchards, as, however thoroughly the orchard trees may be sprayed in the spring, there will always be enough scale upon the trees before fall to cause any nursery trees growing in the vicinity to become at least slightly infested.

Great care in choosing locations for the growing of nursery stock to have them as far away as possible from orchard trees, has always been advised and each year the nurserymen have become more and more convinced of the wisdom of this advice. Among the other preventive measures which have been adapted are, the spraying of nursery stock before growth starts with lime-sulphur solution (1 to 8) and again with more diluted solutions (about 1 to 25) when the larvae of the scale can be found upon the trees in greatest numbers, which will generally be about the 10th of July, and again early in September, depending upon the season and location.

This is followed by careful inspection of the nursery trees before they are dug in October. All infested trees are destroyed and the others fumigated with hydrocyanic acid gas if they have been grown within a half mile of where the San Jose scale has been found within two years.

ORCHARD INSPECTION.

The work in this line has been along three principal lines: (1) watching orchards in sections adjacent to counties which are known to be infected or infested; (2) helping farmers whose orchards are injured by insects or diseases and aiding local inspectors; (3) interesting the fruit growers in townships in which the San Jose scale or other dangerous insects or diseases are known to exist, or in which there is danger of their appearance, and securing the appointment of local inspectors.

For some unknown reason the San Jose scale is spreading to the north very slowly and on the east side of the state it has not been found north of Ithaca, although it was quite general in that village ten years ago. Along the western side of the state no new infestations have been found north of Mason county and it has only appeared in a few localities there and these are being carefully watched. Although it was found in 1909 in two places in Benzie county it is not known to have spread from the three trees upon which it was introduced.

During the summer of 1911 peach yellows and little peach developed to an alarming extent. The latter has been particularly difficult to control, as in many sections of the state its appearance is not well understood and the orchards become badly infected before its presence is suspected. It is then too late to check the spread of the disease.

For this reason it is particularly desirable that local inspectors be appointed in all sections where the fruit growing interests are important.

Considerable attention has been paid to securing the co-operation of the officers and members of the fruit growers' associations in bringing about the appointment of inspectors both in townships where dangerous insects and diseases have appeared and in those with important fruit growing interests in which there is a probability that they may develop.

In the last year or two there has been a wonderful awakening regarding the possibilities in the old apple orchards scattered over the southern part of the state. For years they have been neglected and hence were unproductive, but the appearance of the San Jose scale in many of them made it necessary to spray them and it proved so helpful in the way of controlling other insects and fungi that the trees are now bearing regular crops of fine fruit, at a comparatively small expense. That this could be done was conclusively demonstrated by the writer 20 years ago when it was shown that by three or four applications of fungicides and insecticides the bulk of the crop could not only be increased but the injury from scab could be reduced nearly 90 per cent and a similar decrease would be made in the number of the codling moth.

INSPECTION OF EUROPEAN SHIPMENTS.

Several hundred cases of nursery stock have been imported into Michigan from Europe during the year. A very large proportion of them are of species subject to the attack of the gypsy and brown-tail moths, and these have been inspected. During the last year or two there has been a great improvement in the condition of this class of stock, since the work of inspection was taken up four years ago. At that time it was not uncommon to find from 15 to 25 nests of the brown-tail moth, containing from 6,000 to 10,000 larvae in a single box of trees, but for the last two years they have been quite free from them.

Although it seems hardly possible, judging from the condition of the stock imported four years ago, that the trees brought into the state in previous years were entirely free from infestation, no indication of the presence of either of these insects has ever been found in Michigan nurseries.

WHITE PINE BLISTER RUST.

During the last two or three years a destructive disease upon the white pine, known as the blister rust, has been found in New York and other eastern states upon white pine seedlings imported from France, Germany, Holland and Belgium. As this disease is likely to spread to native pine trees, and as it is quickly fatal to them, a quarantine has been placed upon the importation of white pine trees from Europe.

During the year the undersigned has inspected most of the nurseries in the central and northern part of the state. Deputy Inspector E. W. Allis has looked after the inspection work in the southern counties; F. A. Wilken, H. G. Welch and O. H. Robbins have given attention to both nurseries and orchards in the counties along Lake Michigan, and L. M. Geismar has inspected the northern peninsula nurseries. J. A. Jakway and R. J. Crawford have aided in the work of orchard inspection.

The following list shows the firms which were licensed to grow or sell nursery stock in Michigan during the year.

Respectfully submitted,

L. R. TAFT,

State Inspector of Nurseries and Orchards.

East Lansing, June 30, 1912.

LIST OF LICENSED MICHIGAN NURSERIES, 1911-12.

Alferink, Albert, Holland, No. 5.
Allen Brothers, Paw Paw.
Allis, E. W., Adrian.
Baldwin, O. A. D., Bridgman.
Bashford, C. L., Mason.
Berrydale Experiment Gardens, Holland.
Blake, William, Buchanan.
Blanchard, David A., Portland.
Boehringer Brothers, Bay City.
Bragg, L. G. & Co., Kalamazoo.
Celery City Nursery Co., Kalamazoo.
Cole, Levant, Battle Creek.
Collins, Ward E., Fennville.
Coloma Nursery Co., Coloma.
Coryell, R. J., Birmingham.
Cukerski, Wencel L., Grand Rapids.
Culver, O. B., Colon.
Cutler & Downing, Benton Harbor.
Daly, Thos. W., Watervliet.
Dean, Geo. N., Shelbyville.
Detroit Nursery Co., Detroit.
Dow, H. C., Kibbie.
Dressel, G. L., Frankfort.

Dunham, Enos W., Baroda.
Dutton, Chas. S., Holland.
Dyer, Geo., Benton Harbor.
Elliott, Hanson B., Harbor Springs.
Evergreen Cemetery, 153 W. Washington St., Chicago.
Ferrand. E. & Son, Detroit.
Fisher, Guyon, Fennville.
Flansburgh, C. N. & Son, Jackson.
Flansburgh & Potter Co., Leslie.
Genesee County Nurseries, Flint.
Glenwood Nurseries, Holland.
Greening Nursery Co., Monroe.
Gustin, Chas. F., Adrian.
Hamilton, A. & Son, Bangor.
Havekost, G. H., Monroe.
Hawley, Geo. A., Hart.
Hawley, H. E., South Haven.
Helmer Farm Nursery, Battle Creek.
Hibbler, E. B., Detroit.
Hodges, Ezra & Son, Mayville.
Husted, N. P. & Co., Lowell.
Ilgenfritz' Sons Co., I. E., Monroe.
Jackson, James, Kalamazoo.
Jeffery, James, Sr., Kalamazoo.
Kalamazoo Nurseries, Kalamazoo.
Katzenberg, Val, Saginaw, R. D.
Kellogg Co., R. M., Three Rivers.
Kerr, John W., Montrose.
Knapp, Wm. F., Monroe.
Knight, David & Son, Sawyer.
Lock, Daniel, Union Pier.
Mack, Frank H., Hart.
Marvin, O. F., Holton.
Maudlin Co., E., Bridgman.
Mayer, Michael, Jr., Merrill.
McCormick Nursery Co., Monroe.
Michigan Nursery Co., Monroe.
Miller, Abner, Fennville.
Miller, J. W., Fremont.
Munson, Wm. K., Grand Rapids.
Mutual Nurseries, Monroe.
Myers, P. J., Bridgman.
Negaunee Nurseries & Greenhouses, Negaunee.
Nehmer & Sons Co., Daniel, Ontonagon.
Nelson & Son, J. A., Paw Paw.
Newell, Reuben, Highland Park.
Orchard Lake Nurseries, Orchard Lake.
Pier, Frank D., Leslie.
Pilkinton, S. H., Portland.
Pitcher, W. D., Buchanan.
Pontiac Nursery Co., Detroit.
Powers, Chas. & Son, Douglas.

Prestage Co., J. G., Allegan.
Prudential Nursery Co., Kalamazoo.
Retz, Mathias, Riverside.
Rice, Greta B., Port Huron.
Rokely, J. N., Bridgman.
Schild, H. J., Ionia.
Sheldon, Asa G., Paw Paw.
Singer, W. H., Lapeer.
Smith, E. J., Cheboygan.
Smith, Henry, Grand Rapids.
Smith, R. E., Woodville.
Speyers, Chas. M., Willis.
Spielman Brothers, Adrian.
Stahelin, Co., Fred., Bridgman.
Star Nursery, Big Rapids.
Stephens, John S., South Haven.
Stoddard, L. H., Kalamazoo, R. D.
Stone, John & Son, Hillsdale.
Taplin, Stephen, Detroit.
Thrasher, C. D., Hamburg.
Tossy, L. F., Detroit.
Tuttle & Lanphear, Paw Paw.
Voorhees, C. W., Buchanan.
Weston, A. R. & Co., Bridgman.
Whitten, C. E., Bridgman.
Wildermere Gardens, Royal Oak.
Wise, Ralph, Plainwell.
Wolverine Co-operative Nursery Co., Paw Paw.
Wolverine Nurseries, Detroit.

DEALERS IN NURSERY STOCK.

Augustine, L. D., St. Joseph.
Barnes, C. A., Jackson.
Beattie, Thos., 185 Josephine Ave., Detroit.
Buskirk, J. D., Shelby.
Crowley-Milner Co., Detroit.
Davison Nursery Co., Davison.
Day, Edmund, 802 Hamlin Ave., Jackson.
Fair Oaks Nursery Co., Traverse City.
Fansnaugh & Cross, Bangor.
Freyling & Mendels, Grand Rapids.
Grand Rapids Nursery Co., Grand Rapids.
Hall, Frederick T., Greenfield, No. 1.
Healy, Wm., Bloomingdale.
Herpolsheimer Co., Grand Rapids.
Hotchkiss, C. J., 1220 Holcomb Ave., Detroit.
Hudson Co., J. L., Detroit.
Kingsbury, Lathrop, Muskegon.
Knox & Co., S. H., Buffalo, N. Y.
Lohrman Seed Co., Detroit.
Merrifield Brothers, Bloomingdale.

Merrill, W. F., South Haven.
Nash, Chas. C., Three Rivers.
National Plant, Flower & Fruit Guild, Detroit Branch, Detroit.
Northwestern Nurseries, Traverse City.
Pearson & Co., D. S., 1 Conant St., Grand Rapids.
Phillips, Chas. H., Highland Park.
Radewald, Otto, Niles.
Redmond, Alonzo, Marlette.
Scott, C. H. Traverse City.
Slanker, Frank, Benton Harbor.
Stover, F. J., Traverse City.
Strittmatter, A., 1054 Gratiot Ave., Detroit.
Sumner, John, Sandusky.
Sweet, L. H., McGregor.
Trankla & Co., Chas., Grand Rapids.
Walthers' Department Store, Bay City.
Westgate Nursery Co., The H. L., Monroe.
Winkworth, R. M., 80 Farrar St., Detroit.
Woodside Nursery Co., 161 E. Fulton St., Grand Rapids.

FOREIGN NURSERIES.

Allen Nursery Co., Rochester, N. Y.
Bogue, Nelson, Batavia, N. Y.
Brown Brothers Co., Rochester, N. Y.
Bryant Brothers, Dansville, N. Y.
Bryant, A. & Son, Princeton, Ill.
Cartwright, I. D., Toledo, Ohio.
Charlton Nursery Co., Rochester, N. Y.
Chase, Charles H., Rochester, N. Y.
Chase Nurseries, Geneva, N. Y.
Costich, G. A., Rochester, N. Y.
Davis, Franklin, Nursery Co., Baltimore, Md.
Dreer, Henry A., Inc., Philadelphia, Pa.
Fairview Nurseries, Rochester, N. Y.
Farmers' Nursery Co., Troy, Ohio.
First National Nurseries, Rochester, N. Y.
Harman Co., M. H., Geneva, N. Y.
Hawks Nursery Co., Rochester, N. Y.
Herrick Seed Co., Rochester, N. Y.
Home Nursery Co., Bloomington, Ill.
Hooker, Wyman & Co., Rochester, N. Y.
Huntsville Wholesale Nursery Co., Huntsville, Ala.
Jewell Nursery Co., The, Lake City, Minn.
Knight & Bostwick, Newark, N. Y.
McKay Nursery Co., Pardeeville, Wis.
McGlennon & Kirby, Rochester, N. Y.
Moore, William C. & Co., Newark, N. Y.
Moyer, G. N., Laketon, Ind.
Pennsylvania Nursery Co., Girard, Pa.
Perry Nursery Co., Rochester, N. Y.
Pickett, G. S. & Son, Clyde, Ohio.

Ringler Rose Co., 1112 Rector Bldg., Chicago, Ill.
Simpson, H. M. & Sons, Vincennes, Ind.
Stark Bros. Nurseries & Orchards Co., Louisiana, Mo.
Swain-Nelson & Co., Chicago, Ill.
Weber, Carl H., Greenfield, Ind.
Western New York Nursery Co., Rochester, N. Y.
Willett & Wheelock, North Collins, N. Y.

REPORT OF SUPERINTENDENT OF FARMERS' INSTITUTES.

President J. L. Snyder:

Dear Sir—In no previous year have so many farmers' institutes been held in Michigan, or the interest in the work been so great. One feature has been the general distribution of the meetings. In round numbers there were, in addition to the Round-up Institute, two three-day institutes, and 82 county institutes of which 69 held sessions for two days. Nearly all of the others were in the Upper Peninsula. For the first time in many years an institute has been held in every county in the Lower Peninsula and there was but one county, Keweenaw, in the Upper Peninsula which did not have at least one institute.

In the main, the attendance was excellent but the continued extremely cold weather and the many storms which blocked the railroads and highways literally made it impossible for the people to get out to the institutes in some of the counties. On this account two or three of the one-day institutes were given up entirely and it was necessary to postpone the Montcalm county institute at Stanton because of the severe storm of February 22 to 24.

As usual, the attendance at a large number of the institutes was interferred with by the prevalence of contagious diseases and no less than ten one-day institutes were given up in Jackson, Lenawee and Monroe counties from fear of spread of small pox which prevailed in that section.

INSTITUTE TRAINS.

For a number of years one or more railroad institute trains have been operated during the spring months, but in 1911-12 an innovation was attempted in running a "Better Wheat" special during the month of August, 1911.

The Lake Shore and Michigan Southern, Michigan Central and Cincinnati Northern railroads co-operated in furnishing the train. The following itinerary was followed: Lake Shore road—Lansing to Hillsdale: Hillsdale to Adrian, via Brooklyn; Adrian to White Pigeon; White Pigeon to Grand Rapids. On the Michigan Central railroad the route included the towns between Grand Rapids and Jackson; Jackson and Buchanan, via Three Rivers; Buchanan and Jackson, via Kalamazoo, and from Jackson to Addison Junction upon the Cincinnati Northern road.

The train as usual consisted of three passenger coaches in which lectures were given and four express cars which were used for the exhibits.

The exhibits in one car illustrated the different classes of soils and proper and improper methods of handling them, and another was filled with specimens of some 40 varieties of wheat. The straw, grain and flour of the different varieties, as well as the bread made from them, were shown.

One of the objects of the train was to demonstrate the merits of Michigan grown winter wheat as compared with spring wheat for bread making, as well as pastry. The State Millers' Association co-operated by furnishing as a demonstrator, Miss Agnes Hunt of the Domestic Science department of the Agricultural College, and one car was given up to the ladies. Miss Hunt was provided with a kitchen outfit and both lectured upon and demonstrated the method of preparing the dough when making bread from winter wheat. The domestic science exhibits were in charge of Miss Vesta C. Haney, assistant to the Superintendent of Farmers' Institutes, who demonstrated some of the kitchen utensils, such as fireless cookers, coffee percolators, bread and cake mixers, lunch boxes, etc., and displayed samples of the work done in the Domestic Science and Domestic Art departments of the college.

The State Library and the State Board of Health also co-operated by fitting up very attractive and interesting exhibits. One entire car was occupied by the State Board of Health. The exhibit was in charge of Dr. R. L. Dixon, Secretary of the Board, who was accompanied by Dr. Q. O. Gilbert and T. S. Ainge, of his office force. The car was filled with interesting exhibits, including models, charts and specimens illustrating the dangers from tuberculosis, typhoid fever, impure milk, house flies, etc., and methods of combating and controlling them.

The exhibit from the State Library consisted of sample traveling libraries and of collections of pictures, such as are loaned to schools, granges and other organizations. The car was in charge of Mrs. Mary C. Spencer, State Librarian, and Prof. R. D. Bailey.

The State Millers' Association co-operated further by having upon the train J. H. Prout of Howard City and Harry E. Hooker, Lansing, secretary of the association, one of whom spoke at each place upon the needs of the millers and they advised the farmers regarding the nature of the wheat which would be best adapted to their needs, and for which they could pay the highest price. The importance of keeping the wheat free from smut and from rye, cockle and other weeds, was also urged.

The lecture force from the college included Mr. W. F. Raven, Prof. V. M. Shoesmith, Mr. C. H. Spurway and Mr. Geo. Bouyoucos, who discussed different phases of wheat culture, including the selection of the soil, its place in the rotation, preparation of the land, use of fertilizers, choice of varieties, seeding, etc.

The officers of the county institute societies were aided in advertising the train by the local and agricultural papers, and the by the local millers, health officers and station agents.

The attendance at the train at nearly every stop was as large as could be accommodated, and at several points it was found necessary to open up the exhibit cars after filling all of the seats in the coaches.

The trip lasted eleven days and the interest seemed general. It certainly brought home to the farmers the need of greater care in growing

the wheat crop, and to the ladies the value of flour made from Michigan grown wheat for bread-making and other purposes.

A second railroad institute train was run in June, 1912, for a period of 13 days. It started from Bay City over the Detroit and Mackinac road and spent four days in getting to Cheboygan, returning from there over the Michigan Central railroad to Bay City, where the train was transferred to the Grand Trunk. Two days were spent upon this road upon the Saginaw and Muskegon divisions, and four upon the Ann Arbor between Owosso and Copemish.

The State Library, the State Dairy and Food Department and the State Millers' Association co-operated by furnishing speakers and demonstrators. The trip was very successful although the attendance was somewhat reduced by the rush of farm work at that time.

THE COUNTY INSTITUTES.

The number of farmers' institutes held in Michigan has been steadily increasing. For several years, meetings have been held in all, or particularly all of the counties in the Lower Peninsula and in a majority of the counties in the Upper Peninsula, but during the institute season of 1911-12 county institutes were held in every county south of the Straits of Mackinaw and in all but Keweenaw county in the Upper Peninsula.

With few exceptions, the meetings included five sessions, beginning in the forenoon of the first day and concluding with the afternoon session of the second; a few counties, however, held two-day institutes with six sessions and others extended the program over three days.

The success of the county institutes was almost always in proportion to the ability of the secretary of the county institute society and the interest taken by him in perfecting the local arrangements, and in advertising the meetings.

The largest attendance was at the Saginaw county institute which was held at the Burt Auditorium in the city of Saginaw. Some years ago when meetings were held in Saginaw they were but poorly attended, the farmers taking very little interest in the institutes held in the city, although when they were held at other points a goodly number attended. It was frankly stated that it was not possible to hold a successful farmers' institute in a large city, and especially in Saginaw. This year, by securing the co-operation of the Saginaw Board of Trade, the meeting was thoroughly advertised and an attendance of fully 2,000 was secured at each of two of the sessions and the auditorium was always well filled. A valuable feature of this institute was an exhibit of agricultural products by farmers, and of implements and tools, which would be of interest to farmers, by a number of manufacturers.

It was unquestionably one of the most successful and helpful farmers' institutes ever held in Michigan and the credit is very largely due to the efficient secretary of the Saginaw Board of Trade, Mr. J. P. Tracy, who was indefatigable in his efforts to make the institute a success. One of his methods for advertising the institute is commended to the officers of institute societies in other counties. It consisted in furnishing reading notices regarding plans for the institute, the speakers, etc., to the newspapers for several weeks before the date of the meeting, and in sending cards, circulars and programs to farmers all over the county. While

more or less of this has been done in most of the counties, it has never been followed up so persistently as has been done this year at Saginaw and it has been fully justified by the results. Many secretaries claim that they do not have money to advertise the institute, but, if it is looked after properly, the more that is spent for advertising the greater will be the balance in the treasury at the end of the season.

ONE-DAY INSTITUTES.

Nothing shows better the appreciation of farmers' institutes on the part of farmers than the number of requests for more meetings, or for a larger number of speakers.

In both, the number has been limited by the amount available for institute work. Whether there should be one speaker, or two or more, at each one-day institute has been discussed nearly every year at the conferences of lecturers and institute officers at the Round-Up Institute, and it has generally been agreed that it is better to have 350 institutes with one state speaker than 175 institutes with two speakers.

No effort whatever was made to secure more one-day institutes as it was felt that without it, there would be more calls than could be filled.

With a very few exceptions, several one-day institutes were held in all of the counties, in addition to the county institute. That such meetings would be found helpful in all of the counties is seen from the fact that the counties which are holding the largest number of meetings and which have the largest attendance are in the southern part of the state, which is the oldest, and naturally has made more advancement along agricultural lines than the more northern counties. While the average number of one-day institutes has been less than five per county, quite a number of the southern counties have held from 12 to 16, and more could have been readily located. At a considerable number of the institutes the seats were filled at one or more of the sessions, and at quite a number of places even standing room was not available, and 100 or more persons were unable to gain admission to the building.

THE LECTURERS.

Each year owing to the increase in the number of students, it is becoming more difficult for the members of the college faculty to leave their classes for any length of time, for the purpose of attending institutes, and more and more it has become necessary to look outside for lecturers, even to a greater extent than in previous years. Several of the lecturers on farming topics were also unable to take part in the work during the past year and these two reasons made it necessary to draft into service a number of new men. After considerable investigation, the services of five farmers, most of them graduates of the Michigan Agricultural College, were secured and they entered at once upon their duties. All of them were men who have made a success in some line of agricultural work, and the results fully justified their selection.

The Michigan institutes have again been favored by the presence of speakers furnished by the U. S. Department of Agriculture. Prof. C. B. Smith and Prof. J. C. McDowell each spent two weeks in the state and their efforts received the very highest praise at every point visited by

them. Both of these gentlemen are connected with the Farm Management Bureau, and, as they devote all of their time to studying the methods used by the more successful farmers in this and the neighboring states, and to the carrying on of experiments with various crops upon all classes of soils, no one is better prepared to discuss topics relating to farm crops. Combined with possessing a scientific and practical knowledge of their subjects, they have the rare ability of being able to present them in a clear, concise, and yet interesting form, and to convince every one that they are correct in their conclusions. Quite a number of the members of the college faculty also took an active part in many of the county institutes.

The assistance of the faculty of the State Normal College, at Ypsilanti, and the Western Normal College at Kalamazoo, by furnishing speakers for the evening sessions was also appreciated.

The State Highway Department was represented at fully 40 of the institutes by Deputy Commissioner Frank F. Rogers and Deputy Commissioner James W. Helme of the State Dairy and Food Department, also attended a number of meetings. The State Board of Health and State Library Commission also co-operated by furnishing speakers for the evening sessions upon their special subjects. Principal J. F. Wojta, of the Menominee County School of Agriculture, devoted a number of days to attending the institutes in Menominee county.

The institutes in the Upper Peninsula were held partly in the fall and the remainder in the spring. For the latter series arrangements were made with Deputy State Master, R. N. Seward, of Stephenson, for a series of joint meetings with the Pomona granges. One speaker was furnished by the Institute Department and one by the Grange. Mr. Seward also took charge of and co-operated with the officers of the county institute societies in arranging and advertising the institutes, and he was also present at all of the meetings. That the series was the most successful ever held in the Northern Peninsula of Michigan was largely due to his efforts.

Prof. Henry G. Bell, Agronomist of the National Soil Improvement Committee, Chicago, and Mr. C. K. Arp, Expert of the Universal Portland Cement Co., Chicago, also gave addresses at several of the institutes.

ROUND-UP INSTITUTE.

At the close of the general series a Round-up institute was held at the Agricultural College, beginning Tuesday morning, February 27th and ending Friday afternoon, March 1st.

As for the two previous years, the forenoon sessions were devoted to the continuation of the series of lectures upon soils and crops. Professors J. A. Jeffery and V. M. Shoesmith each gave four lectures, while three were furnished by Dr. C. E. Marshall and his assistants.

The afternoon and evening sessions were occupied with topics more general in their nature, although more than the usual attention was paid to the building up of soils and the handling of farm crops. Most of these addresses were by speakers from other states.

The institute was favored by the presence of such speakers as Dr. Cyril G. Hopkins of the Illinois Experiment Station; Prof. Henry G. Bell, Agronomist of the National Soil Improvement Committee, Chicago;

Prof. Oscar Erf of the Ohio State University; Prof. J. C. McDowell and Prof. A. G. Hammar of the U. S. Department of Agriculture, and Mrs. C. W. Foulk of Columbus, Ohio.

As the use of cement is each year becoming more general, arrangements were made with the Universal Portland Cement Company, of Chicago, for an illustrated lecture upon the use of cement upon the farm, by one of its experts. The lecture contained much useful information and will be found in the body of the report.

The other lectures were by members of the regular lecture force, many of whom also took an active part in the discussion of the different subjects.

EXHIBITS AT ROUND-UP INSTITUTE.

As a rule, the departments of the college prepared special exhibits for the inspection of the visitors. The Bacteriological and Engineering departments in particular had displays which were well worthy of inspection, in their respective laboratories. The Horticultural department had an exhibit of fruit and of horticultural apparatus and methods in one of the upper rooms of the Agricultural Building which attracted much attention.

The Association of Manufacturers of Spraying Machinery and Supplies even surpassed the exhibit made one year previous as they showed some 25 power spraying outfits which gave the visitors a good idea of the spraying outfits sold by the leading manufacturers of this and other states.

The college library, museum, barns, greenhouses, U. S. Weather Bureau, and in fact all of the different laboratories, had many visitors who were thus able to obtain a better idea of the college and its equipment.

MUSIC AT THE ROUND-UP.

As in previous years the college musical organizations added much to the interest of the sessions by the selections furnished. The M. A. C. Band, Girls' Glee Club, Men's Glee Club and several soloists were on the program and their productions were highly appreciated. On Wednesday afternoon the music was furnished by the orchestra and chorus from the School for the Blind, and on Thursday afternoon the boys from the State Industrial School gave several selections both at the general session and the Women's Congress.

CONFERENCES OF LECTURERS AND DELEGATES.

Delegates from some 50 county institute societies were present and joined with the lecturers in holding conferences on Tuesday, Wednesday and Thursday before and after the sessions. Matters relating to the work of the past year were discussed and plans were made for the holding of institutes during the coming year.

Respectfully submitted,

L. R. TAFT,

Supt. Farmers' Institutes.

East Lansing, June 30, 1912.

TWENTY-FIFTH ANNUAL REPORT

OF THE

EXPERIMENT STATION

OF THE

MICHIGAN AGRICULTURAL COLLEGE

UNDER THE HATCH AND ADAMS ACTS

FOR THE

YEAR ENDING JUNE 30, 1912.

For members and organization of the State Board of Agriculture in charge of the Station and list of officers, see page 13 of this volume.

REPORT OF SECRETARY AND TREASURER.

The following shows the receipts and disbursements of the Experiment Station for the year ending June 30, 1912.

	Dr.	Cr.
July 1, 1911—To balance overdrawn	....	$2,548 74
July 14, 1911......received from U. S. Treasury	$7,500 00	
Oct. 17, 1911......received from U. S. Treasury	7,500 00	
Jan. 22, 1912......received from U. S. Treasury	7,500 00	
April 19, 1912......received from U. S. Treasury	7,500 00	
June 30, 1912......license fees, 271 brands com'l fertilizers	5,420 00	
farm and miscellaneous receipts	517 55	
from State appropriation, South Haven Experiment Station	2,000 00	
from State appropriation, U. P. Experiment Station	4,000 00	
South Haven Experiment Station, receipts	332 15	
U. P. Experiment Station receipts	2,284 03	
by disbursements as per vouchers filed in the office of the State Auditor General	....	43,713 77
Balance overdrawn	1,708 78	
Total	$46,262 51	$46,262 51

One hundred seventy-five thousand regular bulletins Nos. 265, 266, 267; fifty thousand special bulletins, Nos. 56, 57, 58; seven thousand technical bulletins No. 11; sixty-seventy thousand circulars Nos. 12, 13, 14, 15, 16, 17; five thousand reprints of circular 5, and twenty-eight hundred Press bulletins Nos. 24, 25, 26, 27, have been issued by the Experiment Station during the fiscal year.

DISBURSEMENTS ON ACCOUNT OF U. S. APPROPRIATIONS.

	Hatch fund.	Adams fund.	Total.
Salaries:			
Director and other administrative officers	$2,120 00	$500 00	$2,620 00
Scientific staff	2,725 00	1,125 00	3,850 00
Assistants to scientific staff	3,675 70	9,461 16	13,136 86
Labor:			
Annual and monthly employees	1,071 20	805 00	1,876 20
Weekly, daily and hourly as needed	1,117 46	115 62	1,233 08
Publications	53 58	....	53 58
Postage and stationery:			
Postage	112 87	1 36	114 23
Stationery	83 55	10 50	94 05
Telegraph and telephone	18 00	....	18 00
Freight and express	85 25	82 31	167 56
Heat, light, water and power	123 67	....	123 67
Chemical and laboratory supplies:			
Chemicals	182 14	307 11	489 25
Other supplies	588 70	650 85	1,239 55
Seeds, plants and sundry supplies:			
Agricultural	73 84	....	73 84
Horticultural	247 42	....	247 42
Botanical	120 58	24 90	145 48
Entomological	69 20	4 00	73 20
Bacteriological	26 71	69 72	96 43
Chemical	38 12	5 75	43 87
Library	67	....	67
Soils	14 02	87 66	101 68

U. S. APPROPRIATIONS.—*Concluded.*

	Hatch fund.	Adams fund.	Total.
Scientific apparatus and specimens:			
One thermograph	$50 00		$50 00
One pair prism binoculars, No. 6	32 50		32 50
One reduction coil	10 80		10 80
One copper gas holder	17 00		17 00
One binocular miscroscope	40 30		40 30
One 12-inch 220 V fan with cord	13 50		13 50
One 1-12 oil immersion	24 30		24 30
One micrometer eyepiece	27 00		27 00
One stirring apparatus	17 96		17 96
One shaking apparatus	38 00		38 00
One Freas Electric Oven		$175 00	175 00
One Freas Water Bath		225 00	225 00
One Freas Shaking Apparatus		150 00	150 00
One meter bridge		22 50	22 50
One calculating instrument		31 50	31 50
Nine resistance bulbs		96 75	96 75
One incubator		135 00	135 00
One percision centrifuge		85 50	85 50
Two combination thermographs		165 00	165 00
One electrical bridge		100 00	100 00
One soil thermograph comp		50 00	50 00
Other purchases	341 52	330 48	672 00
Live stock:			
Small experimental animals	3 50		3 50
Sundries		1 00	1 00
Fertilizers	121 80	5 72	127 52
Library:			
One copy Monographia Uredenearium, Vols. 1 & 2	30 25		30 25
One copy Sylloge Fungorum, Vol. XX	17 22		17 22
One set Genera Insectorum	42 75		42 75
One set Hand Buch biochemischen	42 63		42 63
Six Vol. Central blatt Bakteriologie Erste	21 60		21 60
Four Vols. Central blatt Bakteriologie Erste	21 60		21 60
Four Vols. Central blatt Bakteriologie Erste	14 40		14 40
One copy Chemisches Central Blatt	20 00		20 00
Binding 114 vols	108 30		108 30
One set Genera Insectorum	49 90		49 90
Other purchases	718 75	13 17	731 92
One translation, Effects of Acid on Plants		10 00	10 00
Tools machinery and appliances:			
New purchases	211 35		211 35
Repairs	12 51		12 51
Furniture and fixtures:			
One Remington typewriter	81 00		81 00
One desk	30 00		30 00
Other purchases	19 56		19 56
Traveling expenses:			
In supervision of Station work	51 86		51 86
For other purposes connected with Station work	202 66		202 66
Contingent expenses	25 00		25 00
Buildings and land		152 44	152 44
Total	$15,000 00	$15,000 00	$30,000 00

DISBURSEMENTS OF EXPERIMENT STATION MONEYS—OTHER THAN RECEIVED FROM U. S. TREASURER.

Salaries	$4,065 58	
Labor	5,895 05	
Publications	762 02	
Postage and stationery	217 25	
Freight and express	144 58	
Chemicals and laboratory supplies	213 15	
Seeds, plants and sundry supplies	1,218 72	
Feeding stuffs	50 40	
Library	25 41	
Tools, machinery and appliances	71 60	
Furniture and fixtures	4 15	
Scientific apparatus and specimens	418 08	
Traveling expenses	583 25	
Contingent expenses	2 00	
Buildings and land	42 53	
Total		$13,713 77

REPORT OF THE DIRECTOR OF THE EXPERIMENT STATION.

To President J. L. Snyder:

The time has now come when further extension of experimentation and scientific research is impossible without additional state aid. The Experiment Station has endeavored to procure and retain a staff of well qualified, energetic workers. During the recent past it has been possible to provide working equipment and salaries such as to enable the workers to make satisfactory progress and feel suitably repaid for their services. The Hatch and Adams funds are now so apportioned that they cannot be further drawn upon to procure additional workers or to increase the salaries of the present working force. Therefore unless the the federal appropriations are quite liberally supplemented by state aid during the coming year the activities of the station will be retarded and the retention of the present efficient staff endangered.

With the exception of a few workers exclusively engaged in research most of our men have double duties involving both college and station. With the rapid increase of students in the Agricultural division we are confronted by the danger of absorption of an undue amount of time on the part of instruction work. This danger has been quite markedly manifest during this year.

During the year the following publications have been issued by the Experiment Station, viz:

Bulletin No. 265—Fertilizer Analyses, by A. J. Patten, O. B. Winter and C. G. Clippert.

Bulletin No. 266—Poultry House Construction and Yarding, by H. L. Kempster.

Bulletin No. 267—Michigan Weeds, by W. J. Beal.

Special Bulletin No. 56—Tile Drainage, by J. A. Jeffery.

Special Bulletin No. 57—Revision of Special 54, entitled Spray and Practice Outline for Fruit Growers.

Special Bulletin No. 58—Foul Brood, by R. H. Pettit.

Technical Bulletin No. 11—How Contact Insecticides Kill, by George D. Shafer.

Circular No. 13—Winter Vetch as a Cover Crop for Michigan Orchards, by H. J. Eustace.

Circular No. 14—Top Working Old Apple Trees, by C. P. Halligan.

Circular No. 15—Potato Culture, by H. J. Eustace.

Circular No. 16—Sandy Soils of Western and Northern Michigan, by J. A. Jeffery.

Circular No. 17—The Michigan Woodlot, by J. Fred Baker.

Press Bulletin No. 25—Announcement of Special Bulletins 56 and 57.

Press Bulletin No. 26—Forestry Extension Work, by R. S. Shaw.

Press Bulletin No. 27—Germinating Qualities of Seed Beans in Michigan, by V. M. Shoesmith.

The following changes have been made in the organization of the work in the Upper Peninsula. At a meeting of the State Board of Agriculture held March 20th, Mr. L. M. Geismar, Superintendent of the Sub-station at Chatham was offered the position of Agricultural Extension Expert for the Upper Peninsula which he accepted, transferring his headquarters to Marquette, Mich. Mr. Roswell G. Carr an M. A. C. graduate of 1908 was appointed superintendent of the Sub-station at Chatham to succeed Mr. Geismar.

The activities of the work at Chatham have been greatly enlarged and accelerated. One hundred and sixty acres of cutover timber land on the section recently donated by the Cleveland Cliffs Company is being cleared preparatory to seeding and fencing. On a portion of this tract which produced hardwood timber all refuse is being piled and burned and the small grubs pulled, leaving only the larger stumps with the ground in condition to harrow in the grass seed. On the balance of the area the loose material only is being rough burned so that the seeding will have to be made without any attempt at covering artificially. The work of clearing and seeding is also progressing rapidly on the original 120 acres from which all the timber has been removed except that on 20 acres.

To aid in suppressing weeds, sprouts, etc., on the partially cleared lands, a carload of yearling wethers including 259 head was ordered shipped from Chicago, thus forming the initial trial in the use of sheep in this section as an aid to other land reclamation methods.

The following building operations are now in progress, viz: The erection of a dairy barn 36x72 feet, a poultry house 16x32 feet, and a piggery to accommodate several head of breeding swine and their offspring. It is the plan to stock the farm before the coming winter with a few dairy cattle, sheep, swine and poultry. It is the policy to develop this farm as rapidly as possible from a demonstration rather than an experimental standpoint, though the latter phase will be continued in keeping with the local demands.

Respectfully submitted,

R. S. SHAW,

Director of the Experiment Station.

East Lansing, June 30, 1912.

REPORT OF THE BACTERIOLOGIST.

Director R. S. Shaw:

Sir—The report of the Bacteriological Division of the Experiment Station is herewith submitted in the form of individual papers by the several workers.

Mr. Robbins submits his work with salt solution in the production of hyperimmune serum for hog cholera.

DATA ON HOG CHOLERA WORK—SALT SOLUTION EXPERIMENT.

In connection with the manufacture of hog cholera serum during the past year, an effort was put forth to reduce the cost of manufacture by increasing the supply of virulent material that would prove efficient in hyperimmunizing pigs. In other words, it was our desire to utilize the cholera pigs for virus other than virus blood.

In manufacturing serum by the regular Dorset-Niles subcutaneous methods, the virus pigs are sacrificed merely for their blood and this virus blood is sufficient only to hyperimmunize one pig of equal size to the virus pig. Thus, we can readily see that to reduce cost of manufacturing serum by this method rests to a great extent on reducing cost of virus that will prove efficient.

ORIGIN OF EXPERIMENT.

Taking up the idea put forth by Dr. R. A. Craig of the Indiana Agricultural Experiment Station of using salt solution as a virus when passed through abdominal cavity of virus pigs, we have centered our work upon this factor. It was our desire to determine the value of this saline solution as a virus and advance methods of using it, if possible, that would prove efficient and practical.

As far as I know of Dr. Craig's work along this line at the present writing is the fact that he stated in Bulletin No. 140, issued February, 1910, that he used virulent salt solution to success in hyperimmunizing animals and had secured potent serum from same. In the report of Agricultural Experiment Stations, he states that virulent solution removed from abdomen of virus pigs two hours after injection had proven successful in hyperimmunizing and produced potent sera.

TECHNIQUE EMPLOYED.

Not having an accurate method of testing serum, keeping in mind that the virulence of virus varies according to its source, that the potency of serum varies according to virulence of virus used, amount of virus injected, and condition of pig used for hyperimmune before and after injecting, we found that it required numerous and careful experiments to justify our results, each being run parallel with the Dorset-Niles subcutaneous methods as a check.

In these experiments I used .75% to .85% saline solution. The solution was sterilized and kept so in cotton-plugged flasks. Just before using, it was heated to about 37½° C. It was injected at this temperature by means of a sterile aspirator apparatus, into abdomen of virus pigs, in varying amounts and let remain various lengths of time so that we might determine just what time would prove more satisfactory and the approximate amount to inject. This solution, or that part of it re-

maining unabsorbed, was removed from the abdomen by means of a sterile pipette or a small cup, immediately after killing the pig.

In this work, I have injected 56 virus pigs with saline solution, the injection varying in amount from 20 cubic centimeters to 45 cubic centimeters per pound of body weight and varying in time let remain in abdomen from 3 hours to 14 hours as per the following table of virus pigs, showing amount of injection, time let remain and per cent recovered.

Experimental virus pigs injected intra-abdominally with physiological solution.

No.	Weight.	Amount of NaCl solution injected.	No. cc. per lb.	Time let remain in abdomen.	Amount of virus NaCl recovered.	Percent recov'd.	Av'ge % recov'd.	Amount of virus blood secured.	Approx'te increase of virus blood by NaCl injected.
267	79 lbs.	2,000 cc.	25	3 hours	1,250 cc.	62.5		875 cc.	85
264	110 lbs.	2,750 cc.	25	3 hours	1,975 cc.	71.8	67.1	1,250 cc.	150
270	121 lbs.	3,025 cc.	25	4 hours	1,500 cc.	49.5		1,550 cc.	340
272	81 lbs.	2,025 cc.	25	4 hours	1,550 cc.	76.5		1,550 cc.	740
276	100 lbs.	2,500 cc.	25	4 hours	1,550 cc.	62.0		1,400 cc.	400
278	78 lbs.	1,950 cc.	25	4 hours	1,100 cc.	56.4		1,000 cc.	320
277	122 lbs.	3,000 cc.	25	4 hours	1,300 cc.	43.3		850 cc.	....
461	71 lbs.	1,875 cc.	25	4 hours	1,000 cc.	53.3	56.8	900 cc.	190
433	80 lbs.	1,600 cc.	20	4 hours	650 cc.	40.6	40.6	1,100 cc.	300
284	94 lbs.	2,820 cc.	30	4 hours	1,400 cc.	49.6		1,200 cc.	260
479	68 lbs.	2,040 cc.	30	4 hours	700 cc.	34.3	41.9	600 cc.	....
476	90 lbs.	4,050 cc.	45	4 hours	2,200 cc.	54.8	54.8	1,100 cc.	200
280	82 lbs.	2,460 cc.	30	5 hours	1,500 cc.	65.0		1,100 cc.	280
281	134 lbs.	4,020 cc.	30	5 hours	2,600 cc.	67.1		1,600 cc.	260
282	124 lbs.	3,750 cc.	30	5 hours	2,200 cc.	58.6		1,000 cc.	....
283	108 lbs.	3,300 cc.	30	5 hours	2,600 cc.	78.7		1,650 cc.	560
285	128 lbs.	3,840 cc.	30	5 hours	2,200 cc.	57.0		1,650 cc.	360
290	95 lbs.	2,700 cc.	30	5 hours	1,400 cc.	51.1		1,350 cc.	400
291	96 lbs.	2,880 cc.	30	5 hours	2,000 cc.	62.5		1,100 cc.	140
292	83 lbs.	2,490 cc.	30	5 hours	1,250 cc.	52.2		1,200 cc.	270
422	100 lbs.	3,000 cc.	30	5 hours	1,800 cc.	60.0		1,100 cc.	100
474	76 lbs.	2,300 cc.	30	5 hours	600 cc.	26.0	57.8	1,000 cc.	240
434	88 lbs.	3,000 cc.	35	5 hours	2,000 cc.	66.6		1,100 cc.	220
493	90 lbs.	3,250 cc.	35	5 hours	1,500 cc.	46.1	46.1	1,200 cc.	300
443	75 lbs.	3,000 cc.	40	5 hours	1,200 cc.	40.0		1,100 cc.	350
454	53 lbs.	2,220 cc.	40	5 hours	1,400 cc.	63.0	51.5	1,200 cc.	670
466	60 lbs.	2,700 cc.	45	5 hours	1,300 cc.	48.1		1,100 cc.	500
485	100 lbs.	4,500 cc.	45	5 hours	2,700 cc.	60.0	54.5	1,400 cc.	400
403	117 lbs.	3,000 cc.	25	6 hours	2,000 cc.	66.6		1,600 cc.	430
384	88 lbs.	3,000 cc.	30	6 hours	2,000 cc.	66.6		1,100 cc.	220
431	100 lbs.	3,000 cc.	30	6 hours	1,000 cc.	33.4	50.0	1,700 cc.	700
341	85 lbs.	2,500 cc.	33	6 hours	900 cc.	36.0		1,000 cc.	150
414	85 lbs.	3,000 cc.	36	6 hours	1,600 cc.	53.3		1,000 cc.	150
432	72 lbs.	2,500 cc.	36	6 hours	1,200 cc.	48.0	50.5	1,000 cc.	280
438	73 lbs.	3,000 cc.	40	6 hours	2,000 cc.	66.6		1,400 cc.	670
423a	77 lbs.	3,200 cc.	40	6 hours	1,700 cc.	53.1	59.5	1,000 cc.	230
422b	60 lbs.	2,500 cc.	42	6 hours	1,400 cc.	56.0		1,100 cc.	500
461b	70 lbs.	3,150 cc.	45	6 hours	1,200 cc.	38.0	38.0	1,120 cc.	420
415	104 lbs.	3,000 cc.	27	6½ hours	2,000 cc.	66.6	66.6	1,700 cc.	660
407	107 lbs.	2,500 cc.	23	7 hours	1,000 cc.	40.0	40.0	1,200 cc.	130
286	96 lbs.	3,000 cc.	30	7 hours	1,800 cc.	60.0		1,200 cc.	240
418a	88 lbs.	2,700 cc.	30	7 hours	650 cc.	24.0	42.0	1,200 cc.	320
423b	93 lbs.	3,000 cc.	31	7 hours	1,200 cc.	40.0	40.0	1,200 cc.	270
346	100 lbs.	3,400 cc.	34	7 hours	1,800 cc.	52.9	52.9	1,600 cc.	600
435	78 lbs.	3,000 cc.	38	7 hours	1,300 cc.	43.3	43.3	1,000 cc.	220
431	70½ lbs.	3,000 cc.	42	7 hours	2,100 cc.	70.0	70.0	1,700 cc.	1,000
404	143 lbs.	3,000 cc.	20	7½ hours	2,000 cc.	66.6	66.6	2,400 cc.	970
406	103 lbs.	2,500 cc.	24	7½ hours	1,000 cc.	40.0	40.0	1,100 cc.	70
289	98 lbs.	3,000 cc.	30	7½ hours	2,100 cc.	70.0	70.0	1,200 cc.	220
380	77 lbs.	3,000 cc.	39	7½ hours	2,200 cc.	73.3	73.3	1,200 cc.	430
428	68 lbs.	2,680 cc.	40	7½ hours	2,000 cc.	74.6	74.6	1,000 cc.	320
402	132 lbs.	3,000 cc.	22	8 hours	2,000 cc.	66.6	66.6	1,600 cc.	280
417	92 lbs.	2,700 cc.	30	8 hours	None.	00.0	00.0	1,000 cc.	80
411	84 lbs.	2,000 cc.	24	9 hours	900 cc.	45.0	45.0	700 cc.	....
408	93 lbs.	2,500 cc.	26	11 hours	1,200 cc.	48.0	48.0	1,250 cc.	320
418b	88 lbs.	2,000 cc.	25	14 hours	None.	00.0	00.0	1,200 cc.	320

With the virulent salt solution taken from abdomen of above virus pigs, I have hyperimmunized (43) pigs injecting virus subcutaneously at the rate of from 10 to 20 cubic centimeters per pound of body weight as shown in the following table of hyperimmunes and following data on experiments:

Experimental pigs, hyperimmunized with virus saline solution.

No.	Weight.	Amount virus NaCl injected to hyper.	No. cc. per lb.	Time of virus.	No. cc. per NaCl lb. injected into virus pig.	Percent of injection recovered from virus pig.	Amount virus NaCl injected to Rehyper.	No. cc. per lb.	Time of virus.	Percent of injection recovered from virus pig.	No. cc. NaCl per lb. injected into virus pig.	Total bleedings.	Total amount serum secured.	Result of serum test. No. cc. protected.	Result of serum test. No. cc. failed to protect.
246	84 lbs.	630 cc. NaCl; 420 cc. V. B.	7½; 5	3 hrs.	25	62.5						4	2,700 cc.	35	10-15-20-25-30
247	90 lbs.	450 cc. NaCl; 450 cc. V. B.	5; 5	3 hrs.	25	62.5						4	2,900 cc.		10-15-20-25-30-35
250	90 lbs.	900 cc. NaCl	10	3 hrs.	25	71.8						4	3,000 cc.	35	10-15-20-25-30
329	65 lbs.	650 cc. NaCl	10	4 hrs.	20	40.6						4	2,890 cc.	20	10-15
251	95 lbs.	712 NaCl; 475 V. B.	12½	4 hrs.	25	76.5						4	2,900 cc.	10-15-20	
252	72 lbs.	360 cc. NaCl.; 360 cc. V. B.	5; 5	4 hrs.	25	76.5						4	2,200 cc.	15-20	10
254	118 lbs.	1,475 NaCl	12½	4 hrs.	25	49.5						4	3,400 cc.	10-15-20	
256	106 lbs.	1,060 NaCl	10	4 hrs.	25	62.0						4	3,300 cc.	15-20	10
257	120 lbs.	610 cc. NaCl.; 610 cc. V. B.	10	4 hrs.	25	56.4						4	4,000 cc.	10-15-20	
258	80 lbs.	400 cc. NaCl.; 400 cc. V. B.	10	4 hrs.	25	56.4						4	2,700 cc.	10-20	15
260	128 lbs.	1,300 NaCl	10	4 hrs.	25	43.3						4	4,400 cc.	10-15-20	
330	80 lbs.	800 cc. NaCl	10	4 hrs.	25	53.3						4	3,000 cc.	20	10-15
323	100 lbs.	700 NaCl; 300 V. B.	10	4 hrs.	30	34.3						4	2,700 cc.	20-25	10-15
267	135 lbs.	1,400 NaCl	10	4 hrs.	30	49.6						4	4,500 cc.	10-15-20	
341	110 lbs.	1,100 NaCl	10	4 hrs.	45	54.8						4	3,695 cc.	20	10-15
269	105 lbs.	1,575 NaCl	15	5 hrs.	30	67.1						4	3,800 cc.	15-20	10
268	135 lbs.	2,025 NaCl	15	5 hrs.	30	72.9						4	3,150 cc.	10-15-20	
270	120 lbs.	1,800 NaCl	15	5 hrs.	30	70.0	900 cc. NaCl	7½	9 hrs.	45.0	24	7	4,470 cc.	10-15-20	
262	160 lbs.	2,400 NaCl	15	5 hrs.	30	57.3						4	4,500 cc.	10-15-20	
263	150 lbs.	1,900 NaCl	15	5 hrs.	30	57.3						4	4,600 cc.	15-20	10
290	120 lbs.	600 NaCl; 600 V. B.	10	5 hrs.	30	52.2						4	3,560 cc.	10-15-20	
291	120 lbs.	600 NaCl; 600 V. B.	10	5 hrs.	30	52.2						4	3,500 cc.	10-15-20	
271	120 lbs.	1,440 NaCl	12	5 hrs.	30	70.2						4	3,500 cc.	10-15-20	
322	90 lbs.	600 V. S.; 300 V. B.	10	5 hrs.	30	26.0						4	3,000 cc.	10-15-20	
345	120 lbs.	1,200 NaCl	10	5 hrs.	35	46.1						4	3,320 cc.		
320	100 lbs.	1,000 NaCl	10	5 hrs.	40	63.0						4	3,200 cc.	10-15-20	
334	90 lbs.	900 NaCl	10	5 hrs.	40	40.0						4	2,670 cc.	15-20	10
324	100 lbs.	1,000 NaCl	10	5 hrs.	45	48.1						4	2,785 cc.	20	10-15
342	90 lbs.	900 NaCl	10	5 hrs.	45	60.0						4	3,070 cc.	20	10-15
343	85 lbs.	1,285 NaCl	15	5 hrs.	45	60.0						4	3,085 cc.	15-20	10
309	147 lbs.	2,550 NaCl	18	6 hrs.	30	50.0						4	3,955 cc.	10-15-20	

Experimental pigs, hyperimmunized with virus saline solution.

No.	Weight.	Amount virus NaCl injected to hyper.	No. cc. per lb.	Time of virus.	No. cc. per NaCl lb. injected into virus pig.	Percent of injection recovered from virus pig.	Amount virus NaCl injected to Rehyper.	No. cc. per lb.	Time of virus.	Percent of injection recovered from virus pig.	No. cc. NaCl per lb. injected into virus pig.	Total bleedings.	Total amount serum secured.	Result of serum test. No. cc. protected.	Result of serum test. No. cc. failed to protect.
326	80 lbs.	800 NaCl....	10	6 hrs.	40	53.1	....	....	....	....	....	4	2,895 cc.......	20	10-15
327	82 lbs.	820 NaCl....	10	6 hrs.	40	53.1	....	....	....	....	....	4	3,195 cc.......	20	10-15
336	120 lbs.	1,200 NaCl....	10	6 hrs.	45	38.0	....	....	....	....	....	4	4,195 cc.......	15-20	10
277	225 lbs.	3,650 NaCl....	16	5 hrs. 7 hrs. 7 hrs. 11 hrs.	30 30 30 26	55.4	1,800 cc.......	8 cc.	7 hrs.	52.9	24	7	8,715 cc.......	5-10-15	....
282	232 lbs.	3,350 NaCl....	14½	5 hrs. 8 hrs. 6 hrs.	30 22 25	62.5	1,800 cc.......	8 cc.	5 hrs. 6 hrs.	50.0	30 40	7	8,750 cc.......	10-15	5
283	200 lbs.	3,400 NaCl....	16	5 hrs. 7½ hrs. 7½ hrs.	30 20 30	62.5	1,500 cc.......	7½ cc.	6½ hrs.	66.6	27	7	9,160 cc.......	10-15-20	....
284	230 lbs.	3,100 NaCl....	14	6 hrs. 8 hrs. 5 hrs.	25 22 30	66.6	1,600 cc.......	7½ cc.	6 hrs.	53.3	36	7	9,100 cc.......	10-15-20	....
285	228 lbs.	3,400 NaCl....	14½	5 hrs. 7 hrs. 7½ hrs.	30 23 30	52.7	1,850 cc.......	8 cc.	5 hrs. 7 hrs.	42.0	30 30	7	9,465 cc.......	5-10-15	....
310	98 lbs.	1,470 NaCl....	15	6 hrs. 7½ hrs.	30 30	50.0	....	....	....	....	....	4	3,200 cc.......	15-20	10
303	170 lbs.	3,000 NaCl....	18	6 hrs. 7½ hrs. 6 hrs.	33 39 36	50.0	1,500 cc.......	9 cc.	6 hrs. 6 hrs.	50.0	30 40	7	8,455 cc.......	15-20	10
312	145 lbs.	3,000 NaCl....	20	6 hrs. 3 hrs.	42 48	49.1	1,500 cc.......	10 cc.	6 hrs.	68.0	40	7	6,000 cc.......	20	10-15
308	152 lbs.	3,000 NaCl....	15	7½ hrs. 7½ hrs.	39 40	73.9	....	....	....	....	....	4	4,435 cc.......	20	10-15

Immune pig No. 246, wt. 84 lbs., was hyperimmunized with 7.5 cc. 3 hr. 25 cc. virus NaCl + 5 cc. virus blood from virus pig No. 267, per lb. of body wt.

Autopsy of virus pig No. 267: Numerous petechiae on kidneys. Liver congested. Spleen hemorrhagic. Lungs hemorrhagic. Inguinal glands hemorrhagic and enlarged. Intestines congested. This pig was killed 12 days after inoculation.

Hyperimmune No. 246 was bled 3 times from the tail and then bled to death from carotid artery, 2700 cc. of serum being secured and tested as follows:

Date.	Pig. No.	Weight. (Lbs.)	Material injected.	Result of test.
6-27-11	693	77	2 cc. virus, No. 291......	7-3-11, died. Autopsy: Good cholera lesions.
6-27-11	692	67	10 cc. serum............ 2 cc. virus, No. 291.....	7-3-11, killed in dying condition. Autopsy: Lymph glands and lungs hemorrhagic.
6-27-11	691	66	15 cc. serum............ 2 cc. virus, No. 291.....	7-10-11, died. Cholera lesions.
6-27-11	690	65	20 cc. serum............ 2 cc. virus, No. 461.....	7-10-11, killed. Good cholera lesions.
11- 8-11	454	114	25 cc. serum............ 2 cc. virus, No. 461.....	11-25-11, died. Cholera lesions.
11- 8-11	459	111	30 cc. serum............ 2 cc. virus, No. 461.....	12-1-11, died. Cholera lesions.
11- 8-11	455	129	35 cc. serum............ 2 cc. virus, No. 461.....	Lived.

(NOTE.—Three hour twenty-five cc. virus means virus injected into virus pig at rate of 25 cc. per lb. of body wt. and let remain 3 hours, and so on. Immune pigs made hyperimmune have same number.)

Thus, according to our test of this serum it was not very potent. By the virus pig showing good cholera lesions, I attributed this low potency to the time the virus NaCl remained in abdomen of virus pig, 3 hrs. not being long enough for the saline solution to gain enough virulence.

Immune pig No. 247, wt. 90 lbs., was hyperimmunized with 5 cc. 3 hr. 25 cc. virus NaCl + 5 cc. virus blood, from virus pig No. 267, per lb. of body wt. by the quick subcutaneous method.

Autopsy of virus No. 267. See above.

This hyperimmune was bled 3 times from the tail at intervals of 1 week and then bled to death, 2,900 cubic centimeters of serum being secured. This serum was tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
6-27-11	689	74	10 cc. serum............ 2 cc. virus, No. 291.....	7-6-11, died. Cholera lesions.
6-27-11	688	77	15 cc. serum............ 2 cc. virus, No. 291.....	7-4-11, died. Cholera lesions.
6-27-11	694	78	20 cc. serum............ 2 cc. virus, No. 291.....	7-10-11, died. Cholera lesions.
11- 8-11	447	128	25 cc. serum............ 2 cc. virus, No. 461.....	11-22-11, died. Cholera lesions.
11- 8-11	450	112	30 cc. serum............ 2 cc. virus, No. 461.....	11-23-11. Cholera lesions.
11- 8-11	457	89	35 cc. serum............ 2 cc. virus, No. 461.....	12-6-11, died. Cholera lesions.
11- 8-11	461	72	2 cc. virus, No. 461.....	11-27-11, killed. Cholera lesions.

Immune pig No. 250, wt. 90 lbs., was hyperimmunized with 10 cc. per lb. of body wt. of 3 hr. 25 cc. virus NaCl No. 264 by quick subcutaneous method.

Autopsy of virus pig No. 264: Few petechiae on cortex of kidneys. Lymph glands enlarged and hemorrhagic. Spleen enlarged and of dark color. Coecum ulcerated. Lungs hemorrhagic and intestines congested.

Hyper No. 250 was bled 3 times from the tail and killed, bleedings being made at intervals of one week. 3,000 cubic centimeters of serum were secured and tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
6-16-11	296	80	2 cc. virus, No. 281......	6-26-11, died. Autopsy: Cholera lesions.
6-16-11	297	80	10 cc. serum............ 2 cc. virus, No. 281.....	6-30-11, killed. Cholera lesions.
6-16-11	294	86	15 cc. serum............ 2 cc. virus, No. 281.....	7-4-11, died. Cholera lesions.
6-16-11	295	88	20 cc. serum............ 2 cc. virus, No. 281.....	7-2-11, died. Cholera lesions.
11- 8-11	461	72	2 cc. virus.............	11-27-11, killed. Cholera lesions.
11- 8-11	451	124	25 cc. serum............ 2 cc. virus.............	11-29-11, died. Cholera lesions.
11- 8-11	452	105	30 cc. serum............ 2 cc. virus.............	Lived.
11- 8-11	453	117	2 cc. virus.............	11-30-11, died. Cholera lesions

The three preceding hyperimmunes are the only ones carried through the process of serum manufacture with 3 hour virus NaCl. By autopsies of virus pigs used showing good cholera lesions, I concluded that the time the saline solution remained in abdominal cavities was too short for the solution to gain enough virulence to prove successful in hyperimmunizing, unless large quantities were used.

4 HOUR 20 CC. VIRUS NaCl.

Immune pig No. 329, wt. 65 lbs., was hyperimmunized by the quick subcutaneous method with 10 cc. per lb. of body wt. of 4 hr. 20 cc. virus NaCl from virus pig No. 433.

Autopsy of virus pig No. 433: Few petechiae on cortex of kidneys and on auricles. Spleen enlarged, dark color, and hemorrhagic. Inguinal and sub-lumbal glands enlarged and hemorrhagic. Lungs hemorrhagic. Liver and intestines congested.

Hyperimmune No. 329 was bled 4 times including neck bleeding at intervals of one week, 2890 cc. of serum being secured which was tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
12- 6-11	390	55	20 cc. serum............ 2 cc. virus.	Lived.
12- 6-11	400	42	15 cc. serum............ 2 cc. virus.............	12-23-11, died. Autopsy: Cholera lesions.
12- 6-11	398	37½	10 cc. serum............ 2 cc. virus.............	12-24-11, died. Autopsy: Cholera lesions.

Check pig killed 9 days after inoculation.

4 HOUR 25 CC. VIRUS NaCl.

Pig No. 251, wt. 95 lbs., was hyperimmunized by the quick subcutaneous method with 7½ cubic centimeters of 4 hr. 25 cc. virus NaCl + 5 cc. virus blood per lb. of body wt. from virus pig No. 272.

Autopsy of virus pig No. 272: Kidneys enlarged and congested. Coecum ulcerated. Lymph glands enlarged and congested. Liver of dark color. Lungs hemorrhagic, and heart normal.

Two thousand nine hundred cubic centimeters of serum were secured from hyper No. 251 by bleeding 3 times from tail and then bleeding to death from neck. This serum was tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
8- 1-11	684	86	20 cc. serum............ 2 cc. virus.............	Lived.
8-1-11	685	82	15 cc. serum............ 2 cc. virus.............	Lived.
8-1-11	686	91	10 cc. serum............ 2 cc. virus.............	Lived.
8-1-11	687	62	2 cc. virus.............	8-13-11, died. Autopsy: Cholera lesions.

Immune pig No. 252, wt. 72 lbs., was hyperimmunized by the quick subcutaneous method with 5 cc. of 4 hr. 25 cc. virus NaCl + 5 cc. virus blood per lb. of body wt. from virus pig No. 272.

Autopsy of virus pig No. 272: See above.

This hyperimmune was bled 4 times including killing, 2200 cubic centimeters of serum being secured and tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
8-1-11	675	60½	20 cc. serum 2 cc. virus	Lived.
8-1-11	676	55	15 cc. serum 2 cc. virus	Lived.
8-1-11	677	64½	10 cc. serum 2 cc. virus	8-20-11, died. Autopsy: Cholera lesions.
8-1-11	687	62	2 cc. virus	8-13-11, died. Autopsy: Cholera lesions.

Immune pig No. 254, wt. 118 lbs., was hyperimmunized by quick subcutaneous method with 12½cc. per lb. of body wt. of 4 hr. 25cc. virus NaCl from virus pig No. 270.

Autopsy of virus No. 270: Few petechiae on kidneys. Lymph glands enlarged. Spleen enlarged and hemorrhagic. Heart and lungs normal, and liver congested.

Hyper No. 254 was bled 3 times from tail, then killed. 3400 cc. serum were secured and tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
6-21-11	699	90	20 cc. serum 2 cc. virus	Lived.
6-21-11	698	80	15 cc. serum 2 cc. virus	Lived.
6-21-11	696	80	10 cc. serum 2 cc. virus	Lived.
6-21-11	697	90	2 cc. virus	7-1-11, died. Autopsy: Cholera lesions.

Immune pig No. 256, wt. 106 lbs., was hyperimmunized by quick subcutaneous method with 10 cc. 4 hr. 25 cc. virus NaCl No. 276.

Autopsy of virus No. 276: Numerous petechiae on kidneys. Inguinal and sub-lumbal glands hemorrhagic. Lungs hemorrhagic. Spleen enlarged and hemorrhagic. Congested areas on intestines.

The above hyperimmune was bled 3 times from tail, then killed. 3300 cc. of serum were secured and tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
8-1-11	681	63½	20 cc. serum 2 cc. virus	Lived.
8-1-11	682	73	15 cc. serum 2 cc. virus	Lived.
8-1-11	683	59	10 cc. serum 2 cc. virus	8-14-11, died. Autopsy: Cholera lesions.

Check pig died in 12 days from inoculation.

Pig No. 257, wt. 120 lbs., was hyperimmunized by quick subcutaneous method with 5 cc. 4 hr. 25 cc. virus NaCl + 5 cc. virus blood per lb. from virus pig No. 278.

Autopsy of virus pig No. 278: Lymph glands enlarged and congested. Liver congested. Spleen enlarged and congested. Kidneys containing a few petechiae on cortex and medulla. Lungs hemorrhagic.

Hyperimmune No. 257 was bled 3 times from tail and then killed. 4000 cc. of serum being secured which was tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
8-2-11	301	60	20 cc. serum 2 cc. virus	Lived.
8-2-11	298	44½	15 cc. serum 2 cc. virus	Lived.
8-2-11	299	65	10 cc. serum 2 cc. virus	Lived.
8-2-11	300	57	2 cc. virus	8-16-11, killed. Autopsy: Cholera lesions.

Immune pig No. 258, wt. 82 lbs., was hyperimmunized with 5 cc. of 4 hr. 25 cc. + 5 cc. virus blood per lb. of body wt. from virus pig No. 278 by the quick subcutaneous method.

Autopsy of virus pig No. 278: See above.

This hyperimmune was bled 3 times from tail, then killed. 2700 cc. of serum were secured and tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
10-14-11	458	81½	20 cc. serum 2 cc. virus	Lived.
10-14-11	459	84	15 cc. serum 2 cc. virus	11-14-11, died. Autopsy: Chronic cholera lesions.
10-14-11	462	88	10 cc. serum	Lived.
10-14-11	457	99	2 cc. virus	Died 12 days after inoculation Cholera lesions.

Immune pig No. 260, wt. 128 lbs., was hyperimmunized with 10 cc. per lb. of body wt. of 4 hr. 25 cc. virus NaCl by the quick subcutaneous method from virus pig No. 277.

Autopsy of virus pig No. 277: Numerous petechiae on cortex and medulla of kidneys. Inguinal and sublumbal glands hemorrhagic. Spleen enlarged and hemorrhagic. Lungs hemorrhagic, and heart normal.

Hyperimmune No. 260 was bled 4 times including killing, 4400 cc. of serum being secured and tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
10–14–11	464	76	20 cc. serum............ 2 cc. virus.............	Lived.
10–14–11	460	97	15 cc. serum............ 2 cc. virus.............	Lived.
10–14–11	463	74	10 cc. serum............ 2 cc. virus.............	Lived.
10–14–11	461	74	2 cc. virus.............	11–1–11, killed. Cholera lesions.

Immune pig No. 330, wt. 80 lbs., was hyperimmunized with 10 cc. per lb. of body wt. of 4 hr. 25 cc. virus NaCl from virus pig No. 461.

Autopsy of virus pig No. 461: Numerous petechiae on kidneys. Inguinal and other glands enlarged and hemorrhagic. Spleen enlarged with hemorrhagic areas. Lungs and heart normal.

Hyperimmune No. 330 was bled 4 times including killing, 3000 cc. of serum being secured and tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
12–6–11	401	49½	20 cc. serum............ 2 cc. virus.............	Lived.
12–6–11	393	48½	15 cc. serum............ 2 cc. virus.............	12–28–11, died. Autopsy: Cholera lesions.
12–6–11	392	41½	10 cc. serum............ 2 cc. virus.............	12–27–11, died. Autopsy: Cholera lesions.

Check pig died 9 days after inoculation. Cholera lesions.

We carried through the process of serum manufacture, as shown above, one hyperimmune with 4 hr. 20 cc. virus NaCl used at rate of 10 cc. per lb. of body wt. and 8 hyperimmunes with 4 hr. 25 cc. virus NaCl used at rate of 10 cc. and 12½ cc. per lb. of body wt. all of which produced serum equal in potency to the Dorset-Niles serum, according to our method of testing serum.

4 HR. 30 CC. VIRUS NaCl.

Immune pig No. 323, wt. 100 lbs., was hyperimmunized by the quick subcutaneous method with 7 cc. of 4 hr. 30 cc. virus NaCl + 3 cc. of virus blood per lb. of body wt. from virus pig No. 479.

Autopsy of virus pig No. 479: Kidneys were enlarged and congested. Lymph glands enlarged and hemorrhagic. Spleen hemorrhagic. Liver congested. Lungs hemorrhagic.

Hyperimmune No. 323 was bled from tail 3 times, then bled to death from carotid artery, 2700 cc. being secured and tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
12–2–11	500	122	25 cc. serum............ 2 cc. virus.............	Lived.
12–2–11	495	110	20 cc. serum............ 2cc. virus..............	Lived.
12–2–11	499	116	15 cc. serum............ 2 cc. virus.............	12–15–11, died. Autopsy: Cholera lesions.

Check pig died within 10 days from inoculation. Cholera lesions.

Immune pig No. 267, wt. 135 lbs., was hyperimmunized by the quick subcutaneous method, by injecting 10 cc. per lb. of body wt. of 4 hr. 30 cc. virus NaCl solution from virus pig No. 284.

Autopsy of virus pig No. 284: Numerous petechiae on kidneys. Cortex of lymph glands hemorrhagic. Spleen enlarged and hemorrhagic. Lungs very hemorrhagic. Liver and heart normal. Intestines normal.

Hyper. No. 267 was bled 4 times, including killing, 4500 cc. of serum being secured, which was tested as follows:

Date.	Pig No.	Weight.	Material injected.	Result of test.
10–9–11	433	70	20 cc. serum............ 2 cc. virus.............	Lived.
10–9–11	444	72	15 cc. serum............ 2 cc. virus.............	Lived.
10–9–11	442	74	10 cc. serum............ 2 cc. virus.............	Lived.
10–9–11	441	56	2 cc. virus.............	10–20–11, died. Autopsy: Cholera lesions.

4 HR. 45 CC. VIRUS NaCl.

Immune pig No. 341, wt. 110 lbs., was hyperimmunized by injecting 10 cc. per lb. of body wt. of 4 hr. 45 cc. virus saline solution from virus pig No. 476.

Autopsy of virus pig No. 476: Few petechiae on kidneys. Lymph glands enlarged and hemorrhagic. Lungs hemorrhagic. Spleen enlarged. Intestines ulcerated.

Hyperimmune No. 341 was bled 4 times, 3695 cc. of serum being secured and tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
1–17–12	7	124	20 cc. serum............ 2 cc. virus.............	2–4–12, died. Cholera lesions.
1–17–12	11	87½	15 cc. serum............ 2 cc. virus.............	2–4–12, died. Cholera lesions.
1–17–12	9	106½	10 cc. serum............ 2 cc. virus.............	Lived.

Autopsies of all preceding hyperimmunes: All organs normal. Virus well absorbed, leaving no abscesses.

5 HR. 30 CC. VIRUS NaCl.

Immune pig No. 269, wt. 105 lbs., was hyperimmunized with 5 hr. 30 cc. virus NaCl as follows:

5-21-'11—Injected subcutaneously 1000 cc. virus NaCl from virus pig No. 281.

5-21-'11—Injected subcutaneously 575 cc. virus NaCl from virus pig No. 283, thus making the total virus used 15 cc. per lb. of body wt.

Autopsy of virus pig No. 281: Few petechiae on kidneys. Liver congested. Ulcers on intestines. Lymph glands and spleen enlarged. Heart normal and lungs hemorrhagic.

Autopsy of virus pig No. 283: Numerous petechiae on kidneys. Lungs hemorrhagic. Spleen enlarged and hemorrhagic. Intestines ulcerated.

This hyperimmune was bled 3 times, then killed, 3800 cc. of serum being secured. Autopsy showed all organs to be normal and virus well absorbed. This serum was tested as follows:

Date.	Pig No.	Weight (Lbs.)	Material injected.	Result of test.
8-1-11	672	72	20 cc. serum............ 2 cc. virus.............	Lived.
8-1-11	673	63	15 cc. serum............ 2 cc. virus.............	Lived.
8-1-11	674	58½	10 cc. serum............ 2 cc. virus.............	8-27-11, died. Autopsy: Cholera lesions.

Check pig died 12 days after inoculation. Autopsy: Cholera lesions.

Immune pig No. 268, wt. 135 lbs., was hyperimmunized by injecting 15 cc. per lb. of body wt. of 5 hr. 30 cc. virus NaCl as follows:

5-22-'11—Injected subcutaneously 1300 cc. virus from virus pig No. 281.

5-29-'11—Injected subcutaneously 725 cc. virus from virus pig No. 283.

Autopsy of virus pigs No. 281 and No. 283: See above.

Hyperimmune No. 268 was bled 3 times from tail, then killed, 3150 cc. of serum being secured and tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
8-1-11	669	54½	20 cc. serum............ 2 cc. virus.............	Lived.
8-1-11	670	62	15 cc. serum............ 2 cc. virus.............	Lived.
8-1-11	671	64	10 cc. serum............ 2 cc. virus.............	Lived.

Check pig died 12 days after inoculation. Cholera lesions.

Autopsy of hyper. No. 268 showed all organs normal and virus well absorbed.

Pig No. 270, wt. 120 lbs., was hyperimmunized by injecting 15 cc. per lb. of body wt. of 5 hr. 30 cc. virus NaCl solution as follows:

5-23-'11—Injected subcutaneously 900 cc. virus NaCl from virus pigs No. 281 and No. 280.

5-29-'11—Injected subcutaneously 900 cc. virus NaCl from virus pig No. 283. See preceding autopsies of No's 281-283.

Autopsy of virus pig No. 280: Numerous petechiae on cortex and medulla of kidneys. Lungs hemorrhagic. Liver congested. Spleen enlarged, of dark color, and hemorrhagic. Lymph glands enlarged with cortex hemorrhagic.

Hyperimmune No. 270 was re-hyperimmunized, after being bled 3 times, by injecting subcutaneously 900 cc. 9 hr. 24 cc. virus NaCl from virus pig No. 411.

Autopsy of virus pig No. 411: Spleen enlarged and congested. Kidneys enlarged and congested. Lungs hemorrhagic. Intestines congested.

After re-hyperimmunizing, pig No. 270 was bled 3 times from tail and then killed, making a total of 7 bleedings, and securing 4470 cc. of serum. This hyper. aborted 2 pigs soon after the third bleeding and was given a rest of 3 weeks before re-hyperimmunizing. Autopsy showed all organs normal and virus well absorbed. Serum was tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
8-29-11	389	71	20 cc. serum 2 cc. virus	Lived.
8-29-11	446	65	15 cc. serum 2 cc. virus	Lived.
8-29-11	437	57	10 cc. serum 2 cc. virus	Lived.
8-29-11	397	63	2 cc. virus	9-11-11, died. Autopsy: Cholera lesions.

Immune pig No. 262, wt. 160 lbs., was hyperimmunized as follows:

5-20-'11—Injected subcutaneously 1100 cc. 5 hr. 30 cc. virus NaCl No. 282.

5-27-'11—Injected subcutaneously 1300 cc. 5 hr. 30 cc. virus NaCl No. 285, making a total injection of 15 cc. per lb. of body wt.

Autopsy of virus pig No. 282: Numerous petechiae on kidneys. Coecum ulcerated. Lymph glands enlarged and hemorrhagic. Spleen enlarged and hemorrhagic. Lungs hemorrhagic. Liver and heart normal.

Autopsy of virus pig No. 285: Numerous petechiae on kidneys. Lymph glands enlarged and congested. Intestines ulcerated.

Hyperimmune No. 262 was bled 4 times, 4500 cc. of serum being secured. Autopsy of this pig showed all organs normal and virus well absorbed. Serum was tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
8-29-11	390	71	20 cc. serum............ 2 cc. virus.............	Lived.
8-29-11	398	63	15 cc. serum............ 2 cc. virus.............	Lived.
8-29-11	395	67	10 cc. serum............ 2 cc. virus.............	Lived.
8-29-11	422	58	2 cc. virus.............	9-13-11, killed. Autopsy: Cholera lesions.

Immune pig No. 263, wt. 150 lbs., was hyperimmunized as follows:

5-20-'11—Injected subcutaneously 1100 cc. 5 hr. 30 cc. virus NaCl from virus pig No. 282 (see above autopsy).

5-27-'11—Injected subcutaneously 800 cc. 5 hr. 30 cc. virus NaCl from virus pig No. 285 (see preceding autopsy of No. 285), making a total injection of 13 cc. per lb.

This hyperimmune was bled 3 times from tail and then killed, 4600 cc. of serum being secured. Autopsy showed all organs normal. Serum was tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
8-29-11	429	61	20 cc. serum............ 2 cc. virus.............	Lived.
8-29-11	445	60	15 cc. serum............ 2 cc. virus.............	Lived.
8-29-11	394	66	10 cc. serum............ 2 cc. virus.............	9-10-11, died. Autopsy: Cholera lesions.
8-29-11	437	74	2 cc. virus.............	9-11-11, killed. Autopsy: Cholera lesions.

Immune pig No. 290, wt. 120 lbs., was hyperimmunized by the quick subcutaneous method by injecting 5 cc. of 5 hr. 30 cc. virus NaCl + 5 cc. of virus blood per lb. of body wt. from virus pig No. 292.

Autopsy of virus pig No. 292: Numerous petechiae on kidneys. Spleen enlarged and congested. Inguinal and sublumbal glands enlarged and congested. Lungs hemorrhagic. Liver badly congested. Heart normal. Hyperimmune No. 290 was bled 4 times including killing, 3560 cc. of serum being secured. Autopsy of this hyper. showed all organs normal. Serum was tested as follows:

Date.	Pig. No.	Weight. (Lbs.)	Material injected.	Result of test.
8-29-11	436	60	20 cc. serum............ 2 cc. virus.............	Lived.
8-29-11	434	83	15 cc. serum............ 2 cc. virus.............	Lived
8-29-11	425	70	10 cc. serum............ 2 cc. virus.............	Lived.

Check pig was killed 11 days after inoculation. Autopsy: Cholera lesions.

Immune pig No. 291, wt. 120 lbs., was hyperimmunized by the quick subcutaneous method by injecting 5 cc. 5 hr. 30 cc. virus NaCl + 5 cc. virus blood, per lb. of body wt. from virus pig No. 292. (See preceding autopsy of virus pig No. 292.)

This hyperimmune was bled 3 times from arteries of tail, then killed, 3500 cc. of serum being secured and tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
8–29–11	396	62	20 cc. serum 2 cc. virus	Lived.
8–29–11	440	60	15 cc. serum 2 cc. virus	Lived.
8–29–11	424	65	10 cc. serum 2 cc. virus	Lived.

Check pig died 11 days after inoculation. Autopsy: Cholera lesions.

Immune pig No. 271, wt. 120 lbs., was hyperimmunized as follows:

5-23-'11—Injected subcutaneously 850 cc. 5 hr. 30 cc. virus NaCl from virus pigs Nos. 280 and 281. (See above autopsies of these virus pigs.)

5-29-'11—Injected 590 cc. 5 hr. 30 cc. virus NaCl from virus pig No. 283, making a total injection of 12 cc. per lb. (See above autopsy of virus pig No. 283.)

This hyper. was bled 4 times, including killing, 3500 cc. of serum being secured and tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
8–29–11	392	51 2	20 cc. serum 2 cc. virus	Lived.
8–29–11	400	68	15 cc. serum 2 cc. virus	Lived.
8–29–11	421	66	10 cc. serum 2 cc. virus	Lived.

Check pig died within 12 days.

Immune pig No. 322, wt. 90 lbs., was hyperimmunized by the quick subcutaneous method by injecting 7 cc. of 5 hr. 30 cc. virus NaCl + 3 cc. of virus blood per lb. of body wt. from virus pig No. 474.

Autopsy of virus pig No. 474: Petechiae on kidneys. Lymph glands enlarged and hemorrhagic. Spleen hemorrhagic. Heart normal. Intestines normal. Lungs hemorrhagic.

Hyper No. 322 was bled 3 times from tail, then killed, 3000 cc. of serum being secured. Autopsy of this hyper. showed all organs normal. Slightly necrotic at points of virus injection. Serum was tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
12-2-11	496	132	25 cc. serum 2 cc. virus	Lived.
12-2-11	497	130	20 cc. serum 2 cc. virus	Lived.
12-2-11	494	95	15 cc. serum 2 cc. virus	Lived.
12-2-11	493	90	2 cc. virus	12-11-11, killed. Autopsy: Cholera lesions.

Thus all pigs hyperimmunized with 5 hr. 30 cc. virus NaCl produced sera of good potency.

5 HR. 35 CC. VIRUS NaCl.

Immune pig No. 345, wt. 120 lbs., was hyperimmunized by the quick subcutaneous method by injecting 10 cc. per lb. of body wt. of 5 hr. 35 cc. virus NaCl from virus pig No. 493.

Autopsy of virus pig No. 493: Few petechiae on kidneys. Spleen enlarged and hemorrhagic. Inguinal and sublumbal glands hemorrhagic. Lungs hemorrhagic. Heart and liver normal.

Hyperimmune No. 320 was bled 3 times from tail, then killed, 3200 cc. of serum being secured, and tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
1-17-12	12	79	20 cc. serum 2 cc. virus	Lived.
1-17-12	13	69	15 cc. serum 2 cc. virus	1-30-12, died. Cholera lesions.
1-17-12	14	74	10 cc. serum 2 cc. virus	Lived.

5 HR. 40 CC. VIRUS NaCl.

Immune pig No. 320, wt. 100 lbs., was hyperimmunized by the quick subcutaneous method by injecting 10 cc. per lb. of body wt. of 5 hr. 40 cc. virus NaCl from virus pig No. 454.

Autopsy of virus pig No. 454: Numerous petechiae on kidneys. Lymph glands enlarged and congested. Spleen enlarged and hemorrhagic. Lungs hemorrhagic. Heart normal. Intestines congested. Liver congested.

Hyperimmune No. 320 was bled 3 times from tail, then killed, 3200 cc. of serum being secured. Autopsy of this hyper. showed virus to be well-absorbed and all organs normal. Serum secured was tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
11-22-11	497	118	20 cc. serum............ 2 cc. virus............	Lived
11-22-11	490	96	15 cc. serum............ 4 cc. virus............	Lived
11-22-11	489	90	10 cc. serum............ 2 cc. virus............	Lived.

Check pig died within 10 days of inoculation: Cholera lesions.

Immune pig No. 334, wt. 90 lbs., was hyperimmunized by the quick subcutaneous method by injecting 10 cc. per lb. of body wt. of 5 hr. 40 cc. virus NaCl from virus pig No. 443.

Autopsy of virus pig No. 443: Numerous petechiae on kidneys. Lymph glands enlarged and congested. Spleen enlarged and hemorrhagic. Lungs hemorrhagic.

Hyperimmune No. 334 was bled 4 times, including killing, 2670 cc. of serum being secured and tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
12-14-11	409	52	20 cc. serum............ 2 cc. virus............	Lived
12-14-11	410	53	15 cc. serum............ 2 cc. virus............	Lived.
12-14-11	411	45	10 cc. serum............ 2 cc. virus............	12-28-11, died. Autopsy: Cholera lesions.

Check pig died within 10 days from inoculation. Cholera lesions.

5 HR. 45 CC. VIRUS NaCl.

Immune pig No. 324, wt. 100 lbs., was hyperimmunized by the quick subcutaneous method by injecting 10 cc. per lb. of body wt. of 5 hr. 45 cc. virus NaCl from virus pig No. 466.

Autopsy of virus pig No. 466: Few petechiae on kidneys. Lymph glands enlarged with cortex hemorrhagic. Liver congested. Spleen enlarged and hemorrhagic. Heart normal. Lungs hemorrhagic.

Hyperimmune No. 324 was bled 4 times, 2785 cc. of serum being secured. Autopsy of this animal showed virus to be well absorbed and all organs normal. Serum was tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
12-4-11	388	104	20 cc. serum............ 2 cc. virus............	Lived.
12-4-11	384	97	15 cc. serum............ 2 cc. virus............	12-18-11, died. Autopsy: Cholera lesions.
12-4-11	389	83	10 cc. serum............ 2 cc. virus............	12-28-11, died. Autopsy: Cholera lesions.

Check pig died 9 days after inoculation: Autopsy: Cholera lesions.

Immune pig No. 342, wt. 90 lbs., was hyperimmunized by the quick subcutaneous method by injecting 10 cc. per lb. of body wt. of 5 hr. 45 cc. virus NaCl from virus pig No. 485.

Autopsy of virus pig No. 485: Few petechiae on kidneys. Lymph glands enlarged and congested. Lungs hemorrhagic. Heart normal. Intestines ulcerated. Liver congested. Spleen enlarged and hemorrhagic.

Hyperimmune No. 342 was bled 3 times from tail, then killed, 3070 cc. of serum being secured and tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
1-3-12	374	60	20 cc. serum............ 2 cc. virus.............	1-26-12, died. Cholera lesions.
1-3-12	373	61	15 cc. serum............ 2 cc. virus.............	1-22-12, died. Cholera lesions.
1-3-12	508	63	10 cc. serum............ 2 cc. virus.............	1-23-12, died. Cholera lesions.
1-3-12	507	47	2 cc. virus.............	1-13-12, killed. Cholera lesions.

Immune pig No. 343, wt. 85 lbs., was hyperimmunized by the quick subcutaneous method by injecting 15 cc. per lb. of body wt. of 5 hr. 45 cc. virus NaCl from virus pig No. 485.

(See above autopsy of virus pig No. 485.)

Hyperimmune No. 343 was bled 4 times, 3085 cc. of serum being secured and tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
1-3-12	505	63	20 cc. serum............ 2 cc. virus.............	Lived.
1-3-12	506	61	15 cc. serum............ 2 cc. virus.............	1-23-12, died. Cholera lesions.
1-3-12	509	68	10 cc. serum............ 2 cc. virus.............	1-23-12, died. Cholera lesions.
1-3-12	510	61	2 cc. virus.............	1-18-11, killed. Cholera lesions.

6.HR. 30 CC. VIRUS NaCl.

Immune pig No. 309 was hyperimmunized with 6 hr. 30 cc. virus NaCl as follows:

9-12-'11—Injected subcutaneously 1200 cc. virus NaCl from virus pig No. 384.

10-9-'11—Injected subcutaneously 1350 cc. virus NaCl from virus pig No. 431, this making a total injection of 18 cc. per lb. of body wt.

Autopsy of virus pig No. 384: Numerous petechiae on kidneys. Lymph glands hemorrhagic. Spleen enlarged and hemorrhagic. Liver enlarged and congested.

Autopsy of virus pig No. 431: Petechiae on kidneys. Lymph glands hemorrhagic. Spleen enlarged and containing hemorrhagic areas. Heart normal.

Hyperimmune No. 309 was bled 4 times, including killing, 3955 cc. of serum being secured. Autopsy of this hyper. showed all organs normal.

Tissue slightly colored at points of injection. Serum secured was tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
11–8–11	460	90	20 cc. serum 2 cc. virus	Lived.
11–8–11	......	449	15 cc. serum 2 cc. virus	Lived.
11–8–11	448	104	10 cc. serum 2 cc. virus	Lived.
11–8–11	461	72	2 cc. virus	11–27–11, killed. Autopsy: Cholera lesions.

6 HR. 40 CC. VIRUS NaCl.

Immune pig No. 326, wt. 80 lbs., was hyperimmunized by the quick subcutaneous method by injecting 10 cc. per lb. of body wt. of 6 hr. 40 cc. virus NaCl from virus pig No. 423.

Autopsy of virus pig No. 423: Few petechiae on kidneys. Lymph glands enlarged and hemorrhagic. Heart and lungs normal. Intestines congested. Spleen enlarged and containing hemorrhagic areas.

Hyperimmune No. 326 was bled 3 times from tail, then killed, 2895 cc. of serum being secured. Autopsy of this hyper. showed all organs normal. Serum was tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
12–4–11	387	89	20 cc. serum 2 cc. virus	Lived.
12–4–11	386	69	15 cc. serum 2 cc. virus	1–2–12, died. Autopsy: Chronic cholera lesions.
12–14–11	383	92	10 cc. serum 2 cc. virus	12–25–11, died. Check pig died within 10 days from inoculation. Autopsy: Cholera lesions.

Immune pig No. 327 was hyperimmunized by the quick subcutaneous method by injecting 10 cc. per lb. of body wt. of 6 hr. 40 cc. virus NaCl from virus pig No. 423. (See autopsy above.)

This hyperimmune was bled 3 times from tail, then bled to death from carotid artery, 3195 cc. of serum being secured which was tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
12–6–11	391	64	20 cc. serum 2 cc. virus	Lived.
12–6–11	399	47	15 cc. serum 2 cc. virus	12–24–11, died. Autopsy: Cholera lesions.
12–6–11	397	51½	10 cc. serum 2 cc. virus	12–28–11, died. Autopsy: Cholera lesions.

Check pig died within 10 days from inoculation. Cholera lesions.

6 HR. 45 CC. VIRUS NaCl.

Immune pig No. 336, wt. 120 lbs., was hyperimmunized by the quick subcutaneous method by injecting 10 cc. per lb. of body wt. of 6 hr. 45 cc. virus NaCl from virus pig No. 461-B.

Autopsy of virus pig No. 461-B: Kidneys congested. Lymph glands enlarged with cortex hemorrhagic. Lungs hemorrhagic. Spleen enlarged and hemorrhagic. Heart normal.

Hyper No. 336 was bled 3 times, then killed, 4195 cc. of serum being secured and tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
1–3–12	380	70	20 cc. serum 2 cc. virus	1–24–12, died. Cholera lesions.
1–3–12	375	54	15 cc. serum 2 cc. virus	Lived.
1–3–12	378	39	10 cc. serum 2 cc. virus	1–24–12, died. Cholera lesions.
1–3–12	379	44	2 cc. virus	1–18–12, died. Cholera lesions.

5 HOUR 30 cc.–7 HOUR 24 cc.–7 HOUR 30 cc.–11 HOUR 26 cc. VIRUS NaCl.

Immune pig No. 277 was hyperimmunized as follows:

6-20-'11—Injected subcutaneously 650 cc. 5 hr. 30 cc. virus NaCl from virus pigs Nos. 290-291.

Autopsy of virus pig No. 290: Few petechiae on kidneys. Lungs hemorrhagic. Liver congested. Spleen enlarged. Lymph glands enlarged and hemorrhagic. Intestines congested.

Autopsy of virus pig No. 291: Lungs hemorrhagic. Kidneys congested. Inguinal and sublumbal glands enlarged and congested.

7-3-'11—Injected subcutaneously 1200 cc. 11 hr. 26 cc. virus NaCl from virus pig No. 408.

Autopsy of virus pig No. 408: Few petechiae on kidneys. Liver congested. Lymph glands hemorrhagic. Spleen enlarged. Heart normal. Lungs hemorrhagic.

7-7-'11—Injected subcutaneously 1850 cc. 7 hr. 30 cc. virus NaCl from virus pig No. 286, making a total injection of 18 cc. per lb. of body wt.

Autopsy of virus pig No. 286: Congested lymph glands. Spleen enlarged and hemorrhagic. Few petechiae on kidneys. Lungs and heart normal.

This hyperimmune was bled 3 times from tail, then re-hyperimmunized by injecting subcutaneously 8 cc. per lb. of body wt. of 7 hr. 24 cc. virus NaCl from virus pig No. 346.

Autopsy of virus pig No. 346: Congested lymph glands. Few petechiae on kidneys. Spleen enlarged and hemorrhagic. Lungs hemorrhagic. Heart normal.

After re-hyperimmunizing this hyper. was bled 3 times from tail, then killed.

Autopsy: All organs normal and virus well absorbed. A total of 8715 cc. of serum was secured, which was tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
10–14–11	465	69	15 cc. serum............ 2 cc. virus.............	Lived.
10–14–11	488	74	10 cc. serum............ 2 cc. virus.............	Lived.
10–14–11	485	65	5 cc. serum............ 2 cc. virus.............	Lived.

5 HOUR 30 cc.–8 HOUR 22 cc.–6 HOUR 25 cc.–7 HOUR 30 cc.–6 HOUR 40 cc. – VIRUS NaCl.

Immune pig No. 282, wt. 232 lbs., was hyperimmunized as follows:

6-20-'11—Injected subcutaneously 650 cc. 5 hr. 30 cc. virus NaCl from virus pigs Nos. 290-291. (See autopsies above.)

7-5-'11—Injected subcutaneously 2000 cc. 8 hr. 22 cc. virus NaCl from virus pig No. 402.

Autopsy of virus pig No. 402: Few petechiae on kidneys. Spleen enlarged and hemorrhagic. Lymph glands hemorrhagic.

7-7-'11—Injected subcutaneously 700 cc. 7½ hr. 30 cc. virus NaCl from virus pig No. 289, this making a total injection of 14½ cc. per lb. of body wt.

Autopsy of virus pig No. 289: Few petechiae on kidneys. Spleen enlarged and hemorrhagic. Intestines ulcerated. Lungs hemorrhagic. Liver congested.

This hyperimmune was bled 3 times from arteries of tail, then rehyperimmunized as follows:

8-24-'11—Injected subcutaneously 600 cc. 5 hr. 30 cc. virus NaCl from virus pig No. 422-A.

Autopsy of virus pig No. 422-A: Numerous petechiae on kidneys. Lymph glands enlarged and congested. Spleen enlarged and containing hemorrhagic areas.

8-31-'11—Injected subcutaneously 1200 cc. 7 hr. 30 cc. virus NaCl from virus pig No. 423-b. Thus, in re-hyperimmunizing, 8 cc. per lb. of body wt. was injected.

Autopsy of virus pig No. 423. (See above.)

After re-hyperimmunizing, hyer. No. 282 was bled 3 times from tail, then killed, 8750 cc. of serum being secured. On autopsy, this animal showed all organs normal. No abscesses were formed, however tissue at points of injection appeared inactive, metabolism not being carried on normally. The serum secured was tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
10–14–11	487	67	15 cc. serum............ 2 cc. virus.............	Lived.
10–14–11	468	67	10 cc. serum............ 2 cc. virus.............	Lived.
10–14–11	482	56	5 cc. serum............ 2 cc. virus.............	10–29–11, died. Autopsy: Cholera lesions.
10–14–11	479	68	2 cc. virus.............	10–30–11, killed. Autopsy: Cholera lesions.

5 HOUR 30 CC.–7½ HOUR 30 CC. VIRUS NaCl.

Immune pig No. 283, wt. 200 lbs., was hyperimmunized as follows:

6-20-'11—Injected subcutaneously 700 cc. 5 hr. 30 cc. virus NaCl from virus pigs Nos. 290-291. (See above autopsies.)

7-5-'11—Injected subcutaneously 2000 cc. 7½ hr. 20 cc. virus NaCl from virus pig No. 404.

Autopsy of virus pig No. 404: Numerous petechiae on kidneys. Lymph glands enlarged with cortex hemorrhagic. Spleen enlarged and hemorrhagic. Lungs hemorrhagic. Heart normal.

7-7-'11—Injected subcutaneously 700 cc. 7½ hr. 30 cc. virus NaCl from virus pig No. 289, (see autopsy above), making a total injection of 16½ cc. per lb. of body wt.

This hyper. was bled 3 times from tail, then re-hyperimmunized by injecting 7½ cc. per lb. of body wt. of 6½ hr. 30 cc. virus NaCl from virus pig No. 415.

Autopsy of virus pig No. 415: Lungs hemorrhagic. Liver and spleen congested, the latter being enlarged. Lymph glands enlarged and hemorrhagic. Intestines ulcerated. Few petechiae on kidneys. After re-hyperimmunizing, hyper. No. 283 was bled 3 times from tail, then killed. A total of 9160 cc. of serum was secured and tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
10–6–11	428	94	20 cc. serum............ 2 cc. virus.............	Lived.
10–6–11	436	79½	15 cc. serum............ 2 cc. virus.............	Lived.
10–6–11	439	72	10 cc. serum............ 2 cc. virus.............	Lived.
10–6–11	432	60½	2 cc. virus.............	10–29–11, killed. Autopsy: Cholera lesions.

5 HOUR 30 CC.–6 HOUR 25 cc.–8 HOUR 22 CC. VIRUS NaCl.

Immune pig No. 284, wt. 230 lbs., was hyperimmunized as follows:

6-20-'11—Injected subcutaneously 700 cc. 5 hr. 30 cc. virus NaCl from virus pigs Nos. 290-291. (See above autopsies.)

7-5-'11—Injected subcutaneously 2400 cc. 8 hr. 22 cc.–6 hr. 25 cc. virus NaCl from virus pigs Nos. 403-402.

Autopsy of virus pig No. 403: Few petechiae on kidneys. Lymph glands enlarged and hemorrhagic. Spleen abnormal in size and containing numerous hemorrhagic areas. Heart and lungs normal.

This hyperimmune was bled 3 times from tail, then re-hyperimmunized by injecting 1600 cc. 6 hr. 36 cc. virus NaCl from virus pig No. 416.

Autopsy of virus No. 416: Lymph glands enlarged and congested. Few petechiae on kidneys. Spleen enlarged. Intestines congested. Lungs and heart normal.

After re-hyperimmunizing, this pig was bled 3 times from tail, then killed. Autopsy showed all organs normal. A total of 9100 cc. of serum was secured, which was tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
10-6-11	429	60½	20 cc. serum 2 cc. virus	Lived.
10-6-11	437	84	15 cc. serum 2 cc. virus	Lived.
10-6-11	430	73	10 cc. serum 2 cc. virus	Lived.
10-6-11	431	103½	2 cc. virus	10-19-11, killed. Autopsy; Cholera lesions.

5 HOUR 30 CC.-7 HOUR 23 CC.-7½ HOUR 30 CC. VIRUS NaCl.

Immune pig No. 285, wt. 228 lbs., was hyperimmunized as follows:

6-20-'11—Injected subcutaneously 700 cc. 5 hr. 30 cc. virus NaCl from virus pigs Nos. 290-291. (See above autopsies.)

7-5-'11—Injected subcutaneously 2000 cc. 7 hr. 23 cc. virus NaCl from virus pigs Nos. 406b and 407.

Autopsy of virus pig No. 406: Numerous petechiae on kidneys. Lungs hemorrhagic. Liver and spleen congested. Lymph glands congested.

Autopsy of virus pig No. 407: Numerous petechiae on kidneys. Spleen enlarged and hemorrhagic. Lymph glands hemorrhagic. Liver congested. Heart and lungs normal.

7-7-'11—Injected subcutaneously 700 cc. 7½ hr. 30 cc. virus NaCl from virus pig No. 289. (See above autopsy.) This makes a total injection of 14½ cc. per lb. of body wt.

This hyperimmune was bled 3 times from tail, then re-hyperimmunized as follows:

8-10-'11—Injected subcutaneously 650 cc. 7 hr. 30 cc. virus NaCl from virus pig No. 418.

Autopsy of virus pig No. 418: Few petechiae on kidneys. Lymph glands enlarged and congested. Spleen enlarged and congested. Heart and lungs normal.

8-24-'11—Injected subcutaneously 1200 cc. 5 hr. 30 cc. virus NaCl from virus pig No. 422. (See above autopsy.) Thus making a total injection of 8 cc. per lb. of body wt. in re-hyperimmunizing.

After re-hyperimmunizing, hyper No. 285 was bled 3 times from tail, then killed. Autopsy showed all organs normal. 9465 cc. of serum were secured and tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
10-14-11	467	74	15 cc. serum 2 cc. virus	Lived.
10-14-11	483	56	10 cc. serum 2 cc. virus	Lived.
10-14-11	486	67	5 cc. serum 2 cc. virus	Lived.
10-14-11	474	74	2 cc. virus	10-29-11, killed. Autopsy: Cholera lesions.

6 HOUR 30 cc.–7½ HOUR 30 cc. VIRUS NaCl.

Immune pig No. 310, wt. 98 lbs., was hyperimmunized as follows:

9-12-'11—Injected subcutaneously 800 cc. 6 hr. 30 cc. virus NaCl from virus pig No. 384. (See above autopsy.)

10-9-'11—Injected subcutaneously 670 cc. 6 hr. 30 cc. virus NaCl from virus pig No. 431, making a total injection of 15 cc. per lb. of body wt.

This hyperimmune was bled 3 times from tail, then killed, 3200 cc. of serum being secured, which was tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
11–18–11	456	125	20 cc. serum............ 2 cc. virus.............	Lived.
11–18–11	458	110	15 cc. serum............ 2 cc. virus.............	Lived.
11–18–11	463	120	10 cc. serum............ 2 cc. virus.............	11–29–11, died. Autopsy: Cholera lesions.
11–18–11	......	....	....	Check pig died within 14 days from inoculation. Autopsy: Cholera lesions.

6 HOUR 33 CC.–6 HOUR 36 CC.–7½ HOUR 39 CC. VIRUS NaCl.

Immune pig No. 303, wt. 170 lbs., was hyperimmunized as follows:

9-8-'11—Injected subcutaneously 900 cc. 6 hr. 33 cc. virus NaCl from virus pig No. 341.

Autopsy of virus pig No. 341: Few petechiae on kidneys. Spleen abnormal in size and containing hemorrhagic areas. Lymph glands enlarged and congested. Heart and lungs normal.

9-11-'11—Injected subcutaneously 1200 cc. 7½ hr. 39 cc. virus NaCl from virus pig No. 380.

Autopsy of virus pig No. 380: Lungs hemorrhagic. Liver congested. Intestines ulcerated slightly. Petechiae on cortex of kidneys and auricles of heart.

9-23-'11—Injected subcutaneously 900 cc. mixture of 6 hr. 36 cc. and 7 hr. 38 cc. virus NaCl from virus pigs Nos. 432 and 435, respectively, making a total injection of 18 cc. per lb. of body wt.

Autopsy of virus pig No. 432: Few petechiae on kidneys. Spleen enlarged and congested. Lymph glands enlarged and hemorrhagic. Liver normal. Lungs hemorrhagic.

Autopsy of virus pig No. 435: No petechiae on kidneys, but congested. Lymph glands congested. Spleen enlarged and hemorrhagic. Heart and lungs normal. Intestines dotted with petechiae.

This hyperimmune was bled 3 times from the tail, then re-hyperimmunized by injecting subcutaneously 1500 cc. of mixture of 6 hr. 30 cc. and 6 hr. 40 cc. virus NaCl from virus pigs Nos. 431 and 438.

Autopsy of virus pig No. 438: Few petechiae on kidneys. Lymph glands enlarged and congested. Small ulcers on intestines. Spleen enlarged and hemorrhagic. Heart and lungs normal.

Hyper No. 303 was bled 3 times after re-hyperimmunizing and killed. A total of 8455 cc. of serum was secured which was tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
11-18-11	482	115	20 cc. serum............. 2 cc. virus.............	Lived
11-18-11	483	101	15 cc. serum............ 2 cc. virus..............	Lived.
11-18-11	484	105	10 cc. serum............ 2 cc. virus.............	12-3-11, died. Autopsy: Cholera lesions.
11-18-11	485	101	2 cc. virus............	12-6-11, killed. Autopsy: Cholera lesions.

6 HOUR 42 cc.-7 HOUR 38 cc. VIRUS NaCl.

Immune pig No. 312, wt. 145 lbs., was hyperimmunized as follows:

9-14-'11—Injected subcutaneously 1400 cc. 6 hr. 42 cc. virus NaCl from virus pig No. 422b.

Autopsy of virus pig No. 422b: Numerous petechiae on kidneys. Lymph glands enlarged and congested. Lungs and heart normal. Spleen enlarged and congested. Intestines congested.

9-23-'11—Injected subcutaneously 1600 cc. mixture of 6 hr. 36 cc. and 7 hr. 38 cc. virus NaCl from virus pigs Nos. 432-435. (See above autopsies), making a total injection of 20 cc. per lb. of body wt.

This hyper was bled 3 times from tail, then re-hyperimmunized by injecting subcutaneously 1500 cc. mixture of 6 hr. 40 cc. and 7 hr. 42 cc. NaCl from virus pigs Nos. 431b and 438. (See autopsy of 438.)

Autopsy of virus pig No. 431b: Petechiae on kidneys. Lymph glands enlarged and congested. Spleen enlarged and hemorrhagic. Intestines congested.

Hyperimmune was bled a total of 7 bleedings, including killing, 6007 cc. of serum being secured which was tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
11-18-11	486	110	20 cc. serum............ 2 cc. virus	Lived
11-18-11	487	104½	2 cc. virus............. 15 cc. serum............	12-13-11, killed. Autopsy: Cholera lesions.
11-18-11	488	112	10 cc. serum............ 2 cc. virus.............	12-12-11, died. Autopsy: Cholera lesions.
11-18-11	485	101	2 cc. virus.............	12-6-11, killed. Autopsy: Cholera lesions.

7½ HOUR 40 cc. VIRUS NaCl.

Immune pig No. 308, wt. 152 lbs., was hyperimmunized as follows:

9-11-'11—Injected subcutaneously 1000 cc. 7½ hr. 39 cc. virus NaCl from virus pig No. 380. (See above autopsy.)

10-14-'11—Injected subcutaneously 2000 cc. 7½ hr. 40 cc. virus NaCl from virus pig No. 428, making a total injection of 20 cc. per lb. of body wt.

Autopsy of virus pig No. 428: Petechiae on kidneys. Lymph glands enlarged and hemorrhagic. Spleen enlarged and hemorrhagic. Lungs hemorrhagic.

This hyperimmune was bled 4 times, including killing, a total of 4435 cc. of serum being secured, which was tested as follows:

Date.	Pig No.	Weight. (Lbs.)	Material injected.	Result of test.
11-11-11	472	111	20 cc. serum............ 2 cc. virus.............	Lived.
11-11-11	475	91	15 cc. serum............ 2 cc. virus.............	12-23-11, died. Cholera lesions.
11-11-11	474	85	10 cc. serum............ 2 cc. virus.............	Lived.
11-11-11	471	74	2 cc. virus.............	11-20-11, died. Autopsy: Cholera lesions.

SUMMARY.

It is impossible at present to state just how salt solution gains its virulence when injected into the abdomen of virus pigs and knowing very little of this ultra-microscopic virus causing hog cholera, it is impossible to determine just how virulent this solution may get. The virulence no doubt varies greatly with different pigs even though autopsies correspond. As well as gaining virulence by taking up this virus from organs and abdominal walls by contact and by growth, it seems that this solution is subjected to osmosis which probably increases its virulence. As far as our methods of standardizing virus go, we fail to see a decrease in virulence of virus blood due to injecting salt solution, although the virus blood is considerably increased by the injection.

It is generally admitted by serum manufacturers that the amount of virus blood secured from virus pigs averages about 10 cubic centimeters per pound of body weight. Accepting this as a standard, I have endeavored to calculate the per cent of increase of virulent material secured when salt solution was injected intra-abdominally as follows:

No. of pigs used.	Rate of injection, per lb.	Time let remain.	Average % of increase.	Value of virus NaCl.
2	25 cc.	3 hrs.	183	Produced sera of low potency when used at rate of 10 cc. 12½ cc. per lb. of body wt. of immune.
6	25 cc.	4 hrs.	147	Produced potent sera when used at rate of 10 cc.–12½ cc. per lb. in hyperimmunizing.
2	30 cc.	4 hrs.	142	Produced potent sera when injected at rate of 10 cc. per lb in hyperimmunizing.
1	45 cc.	4 hrs.	266	Produced sera of low potency when used at rate of 10 cc. per lb.
10	30 cc.	5 hrs.	199	Produced very potent sera when injected at rate of 10 cc.–12 cc.–15 cc. per lb. in hyperimmunizing.
2	40 cc.	5 hrs.	282	Produced potent sera when used at rate of 10 cc. per lb. in hyperimmunizing.
2	45 cc.	5 hrs.	306	Produced sera of low potency when used at rate of 10 cc. per lb. in hyperimmunizing.
1	25 cc.	6 hrs.	156	Produced potent sera.
2	30 cc.	6 hrs.	213	Produced very potent sera when used at rate of 18cc. per lb. in hyperimmunizing.
1	33 cc.	6 hrs.	125	Produced potent sera.
2	36 cc.	6 hrs.	205	Produced potent sera when used with other virus.
3	40 cc.	6 hrs.	309	Produced sera of low potency when used at rate of 10 cc. per lb. in hyperimmunizing.
1	45 cc.	6 hrs.	231	Produced serum with fair potency when used at rate of 10 cc. per lb.
1	27 cc.	6½ hrs.	255	Produced potent sera.
3	30 cc.	7 hrs.	161	Produced very potent sera when used with other virus in hyperimmunizing.
1	34 cc.	7 hrs.	240	Produced potent sera.
1	38 cc.	7 hrs.	196	Produced potent sera when used with other virus in hyperimmunizing.
2	40 cc.	7½ hrs.	455	Produced sera of low potency when used at rate of 15 cc. per lb. in hyperimmunizing.
1	22 cc.	8 hrs.	172	Produced very potent sera when used together with other virus.
1	24 cc.	9 hrs.	102	Produced potent sera when used together with other virus.
1	26 cc.	11 hrs.	163	Produced very potent sera.
1	25 cc.	14 hrs.	36	

These data may be briefly summarized as follows:

We found that the virulence of salt solution injected into the abdominal cavity of virus pigs varies greatly with amount of injection as well as time let remain.

The per cent of injected solution recovered varies greatly with size and age of pig as well as with time let remain in abdominal cavity.

Salt solution injected into the abdominal cavity of virus pigs in amounts not exceeding 30 cc. per pound of body weight and let remain not less than five hours, or for a longer time, was found to be efficient in hyperimmunizing animals.

Since completing this experiment, I have hyperimmunized about 100

pigs, using 6 hour, 30 cc., virulent saline solution, together with virus blood and all have produced very potent sera.

Thus, these results look suggestive of a considerable saving in the cost of manufacturing serum.

OTHER WORK.

In addition to the work with salt solution, I hyperimmunized eight pigs with extract from virus pigs. Six of these animals died from septic infection and two produced potent sera. It seems feasible that the extract from virus pigs may prove efficient as a virus for hyperimmunizing where proper caution is taken in securing and using it.

W. S. ROBBINS.

To Miss Rademacher belongs the commercial phases of the laboratory which includes the shipping of hog cholera serum, the preparation of legume cultures, and the distribution of tuberculin.

She furnishes the following summary:

SERUM REPORT.

July 1, 1911–July 1, 1912.

Current Items of Expense—Not Total.

Feed, concentrated	$750 00
Hay, straw and roughage	200 00
Swine	4,355 44
Apparatus and sundry	450 00
Labor	2,367 70
	$8,123 14

Value of Receipts and Products on Hand.

Actual receipts for serum and virus	$12,099 30
Actual receipts for pigs	1,683 52
Value of tested serum on hand, 1st class	4,321 40
Value of tested serum on hand, 2nd class	328 60
Value of untested and unmixed serum on hand	597 50
Value of hogs on hand in work	458 60
Value of hogs on hand not in work (market price)	261 91
	$19,750 83
Deducting value of products on hand July 1, 1911	4,295 34
Actual value of products to date	$15,455 49

SERUM.

Total No. cc. on hand—good, July 1, 1911	62,301 cc.
Total No. cc. on hand—not tested, July 1, 1911	133,430 cc.
Total No. cc. on hand—poor, July 1, 1911	4,481 cc.
Total No. cc. on hand—drawn and mixed, July 1, 1911–July, 1, 1912	714,115 cc.
Total No. cc. on hand—drawn, not mixed	12,000 cc.
Total No. cc. on hand—experimental serum, July 1, 1911	2,602 cc.
Total No. cc. error in mixing	911 cc.
	929,840 cc.
Total No. cc. sold July 1, 1911–July 1, 1912	602,939 cc.
Total No. cc. used for testing and experiment during year	8,751 cc.
Total No. cc. mixed and tested serum on hand, 1st class	216,070 cc.
Total No. cc. mixed and tested serum on hand, 2nd class	32,860 cc.
Total No. cc. not mixed and not tested on hand	59,750 cc.
Total No. cc. poor serum destroyed	7,083 cc.
Total No. cc. breakage and error	2,387 cc.
	929,840 cc.

No. of cattle tested for tuberculosis	1,574
No. of cattle reacted	13.5%
No. of cattle suspicious	1.4%
No. of doses tuberculin used during year	2,224
No. of doses still on hand	110
No. of doses not reported upon	367

GLANDERS TEST.

No. of horses tested for glanders	14
No. of horses reacted	1

DISTRIBUTION OF SERUM DURING THE YEAR.

1.	Michigan	201,704 cc.
2.	Nebraska	196,750 cc.
3.	Ohio	83,495 cc.
4.	Kentucky	44,445 cc.
5.	Indiana	36,100 cc.
6.	Maine	14,200 cc.
7.	New Jersey	8,250 cc.
8.	Maryland	7,165 cc.
9.	Illinois	6,030 cc.
10.	Missouri	2,500 cc.
11.	Massachusetts	1,000 cc.
12.	Montana	1,000 cc.
13.	Wisconsin	300 cc.
		602,939 cc.

CULTURES.

No. of cultures alfalfa sent out	3,134
No. of cultures red clover sent out	213
No. of cultures alsike clover sent out	21
No. of cultures white clover sent out	6
No. of cultures soy beans sent out	137
No. of cultures white beans sent out	10
No. of cultures peas sent out	74
No. of cultures cowpeas sent out	82
No. of cultures sweet peas sent out	1
No. of cultures vetch sent out	75
	3,753
No. of cultures for which collections are outstanding	51
No. of cultures sent gratis	26
No. of alcohol-acetic cultures sent out	12
No. of lactic cultures	2

Dr. Giltner submits his experiences with avian tuberculosis and his work as State Veterinarian.

AVIAN TUBERCULOSIS.

We have observed a number of new outbreaks of tuberculosis in chickens during the year. A lecture and demonstration before the short course students in poultry resulted in disclosing this disease in several places.

Experimentally, we have not been able to accumulate very much data, hence valuable results are not at hand. Mr. Himmelberger has succeeded in cultivating the avian turbercle germ on sterile banana slants, transfers being made from potato broth which had been inoculated from potato slants. Avian tuberculin has been made and its action tested in a limited manner by injection into the comb and by instillation into the conjunctival sac of chickens without result.

Our tests do not indicate that cohabitation surely or quickly results in the transmission of the disease. Of seven white leghorn hens kept in company with and later in uncleaned pens occupied by tuberculous hens, none showed lesions of tuberculosis after several months. More recent tests with healthy hens kept in intimate association with tuberculous birds in advanced stages of the disease fail to show transmission of the disease after five weeks. We have also been unable to transmit the disease to white rats kept in cages occupied by tuberculous birds or by subcutaneous injections of pure cultures. These experiments are being continued.

We cannot report satisfactorily on the diagnosis of this disease by microscopic examination of smears of fecal matter secured either by

swabs through the cloaca or from droppings. One case in particular failed to show tubercle bacteria after such examination, although fatally affected with the disease. An examination was made only four days before death.

Some apparent relationships between the etiologic organism in Jöhne's disease of cattle and that of avian tuberculosis have induced us to test the effects of the avian germ on calves. On May 17, 1911, twin calves about two weeks old were fed in milk the finely chopped organs of a tuberculous hen. The organs were seriously affected. This material was entirely eaten only after two days. Slight diarrhea supervened and rapidly disappeared. On July 5th, the male calf died suddenly from acute tympanites. No effects of the ingestion of tubercle germs could be seen at autopsy. On July 16th and 17th, the female calf was tested with avian tuberculin. A normal calf was also tested at this time. The tuberculin was made by cultivating the avian tubercle germ in potato broth for eight weeks and evaporating to one-fifth its original volume. The concentrated solution was preserved in .5 per cent phenol.

	Before injection.				Inject'n.	After injection.						
	2 p. m.	4 p. m.	6 p. m.	8 p. m.	8 p. m.	4 a. m.	6 a. m.	8 a. m.	10 a. m.	12 m.	2 p. m.	4 p. m.
Lab. calf....	102.2	102.3	102.2	102.6	3 cc.	105.2	105	104.3	105.3	106	106	105.2
Normal calf..	101	101.7	101.7	101.8	3 cc.	101.6	101.1	101	101.5	101.4	101.4	......

The laboratory calf had a slight diarrhea during the reaction. At 2 p. m. on the next day, the temperature was 103.2°. We are unwilling to sacrifice this calf for the purpose of verifying this test by autopsy, but this will be done later.

Twort and Ingram[1] state that, "Animals suffering from pseudo-tuberculous enteritis, either normally contracted or experimentally produced by the inoculation of pure cultures of Jöhne's bacillus, give no definite reaction with diagnostic vaccines prepared from cultures of the timothy grass bacillus or from avian tubercle bacillus." If our calf has really developed lesions of tuberculosis as a result of ingestion of avian tubercular material, then we have evidence against there being any relation between the two diseases under discussion.

WARD GILTNER.

1. Proc. Roy. Soc. Ser. B. 84 (1912) No. B575, pp. 517-542.

REPORT OF WORK AS STATE VETERINARIAN.

In May, 1911, I was appointed by Gov. Osborn to the office of State Veterinarian to complete an unexpired term, and on July 1st of the same year I was reappointed for the term of two years ending July 1, 1913. This appointment was made at the request of the representatives of the State Board of Agriculture with the idea that it would be for the mutual interests of the College and Experiment Station on the one hand and of the State Live Stock Sanitary Commission and live stock interests of the state on the other. We trust that no one has been disappointed more than the recipient of the honor of the appointment.

The pleasantest of relations have existed in the pursuit of all the duties of the office, but it is well to call attention to the serious interference with real research and satisfactory teaching that has resulted from enforced absence from the laboratory. Most of the work reported here is of a routine nature that it is felt could be performed by another, under suitable direction, with the result that our time could be more profitably devoted to instruction and research, the demand for which is apparent.

Correspondence connected with this work has been a great consumer of time, but it may well be classed as valuable extension work. It is significant that much of this correspondence is impersonal, i. e., letters come to the State Capitol and to the Agricultural College for the State Veterinarian from residents of the state who seem to expect naturally that the State Veterinarian is to be reached in this manner, although they are not informed as to who is the official. This indicates that the office of State Veterinarian should be located at the Michigan Agricultural College. After my appointment, the members of the Live Stock Sanitary Commission were notified that it was my intention to attend the University of Chicago for the summer, consequently I was not called upon until August, 1911.

August 5.—Made autopsy on 7 reacting cattle near Zeeland, 5 of which showed supramammary glands affected. No involvement of mammary gland. The animals should have been used for beef.

August 9.—Visited Perronville and Whitney where 2 herds of cattle were recovering from foot-rot. Cause seemed to be local. No B necrophorus could be isolated.

August 11.—At Ashley, found very extensive losses in sheep due to stomach worms (H. contortus). Attending veterinarians and farmers at a loss to account for deaths. Dense ignorance of commonest sheep disease manifested.

August 15.—At Mulliken, found Red Poll cow suffering from malignant catarrh. Similar cases reported in previous annual report of bacteriologist.

August 21.—At Lowell, killed 4 fat Red Poll cattle. All showed slight lesions of tuberculosis and would have passed federal meat inspection. Should have been used for beef.

August 30.—A horse near Kalamazoo examined for glanders.

September 2.—Tested 9 cows near Zeeland on farm of J——— K———. Five reacted. Stables and watering facilities in most unhygienic condition.

September 5.—Near Adrian, drew 4 samples of blood from horses reported on account of suspicion of glanders. Serum tests resulted negatively. An examination of a portion of lung tissue said to have come from a glandered horse on this farm resulted in revealing emphysema only.

At Onsted, found a severe outbreak of hog cholera. Serum treatment was used on neighboring farm.

September 6.—Drew blood from horse near Kalamazoo noted under August 30. Serum tests resulted negatively.

September 7.—Killed a heifer at Bath. Actinomycosis of the tongue.

September 11.—A cow at Hope suspicious of being tuberculous was slaughtered at owner's request. The cow was in excellent physical condition. All the subcutaneous lymph nodes were greatly enlarged, showing very prominently, especially the parotid, submaxillary, prescapular, precrural and supramammary. Internally, the same condition was found. The lymphatics of the sublumbar region approached the size of the animal's liver. The wall of the uterus (pregnant) was greatly thickened with lymphatic tissue. It was reported that similar cases had occurred in the neighborhood. We had recently seen a case on a farm near the college. Diagnosis: Hodgekin's disease.

September 25.—Tested 8 cows at Atlas. No reactions.

October 6.—Examined horse at Cambridge. Horse very weak in hind quarters. Temp. 103°. Eating fairly well. Coat thin and soft. Mucosae pale, slightly yellowish. Slight oedema of sheath and interaxillae and stocking of legs. Heart enlarged and impact of beat felt over entire thorax. Respirations labored at least exertion. Action of bowels and kidneys appeared normal. Jugular blood very thin, coagulated slowly. Erythrocytes formed about one-fifth of volume at bottom of bottle, buffy coat contained particles like disintegrated erythrocytes.

On October 11, horse was unable to stand. Temp. 98°. No appetite since October 6. Blood from jugular showed fewer erythrocytes and less coagulability. Little oedema. Appeared weak as from hemorrhage.

Autopsy: Brain pale, meninges slightly oedematous, slight ecchymoses in subcutem, oedema variable, lymph nodes generally oedematous and hemorrhagic, thymus very hemorrhagic (larger than normal), lungs considerably oedematous and emphysematous with rupture of air sacs, also ecchymoses on visceral pleura of cephalic lobes. The chambers of the heart are greatly dilated but the walls are not hypertrophic, slight sub-epicardial hemorrhage and epicarditis of left side, pericardial sac contains about one liter of amber-colored fluid; liver is enlarged and engorged with blood; pancreas normal; spleen greatly enlarged with tense capsule and pulp like blackberry jam, splenic lymph nodes hemorrhagic, enlarged and oedematous, gastro-intestinal tube nearly empty, kidneys greatly enlarged and oedematous, bladder distended with pale urine. Diagnosis: Infectious anaemia.

This horse had been sick since June, 1911. The owner had lost two cases previously.

October 26.—Injected 9 cc. of blood serum from above described case into jugular vein of horse belonging to the veterinary department. Tem-

peratures were taken twice daily until November 7. On November 2 the highest temperature was recorded as 101°. No effects of the injection could be seen. The horse was killed January 4, 1912, and it was reported that the blood was notably pale and watery.

October 13.—Tested 3 cows at the Altenheim, Monroe. One reacted. Of the other two, one coughed and the other was greatly emaciated.

October 15.—Tested a herd of 14 cattle at Flat Rock, nearly all reacted. (Records of test kept by commission.)

October 18.—Examined flock of sheep at Bellevue for sore mouth and foot-rot. Not serious. Healing spontaneously.

October 20.—Tested 5 cows at Borculo for Mr. B———. Three reacted.

October 27.—Tested 60 cattle for Wayne County Farm at Eloise. Bull only reacted. Bull came from a notoriously affected herd.

October 30.—Autopsied cow at Imlay City. Impaction of omasum with secondary disturbances. Probably corresponds to Grand Traverse disease.

November 4.—Tested herd of Mr. G———, Zeeland. One reacter. Owner reported that one non-reacter, that was suspicious, gave a severe constitutional reaction 36 hours after the injection.

November 10.—Autopsied reacter at Zeeland on farm of Mr. G———, and at Borculo on farm of Mr. B———. These cattle should have been used for beef with one exception.

November 14.—Investigated outbreaks of hog cholera at Hartford. Local stock yards must have been badly infected.

November 25.—Autopsied cattle on farm of Mr. J——— K——— at Zeeland, tested September 2. Stables still unsanitary. Cattle should have been used for beef.

December 4.—Attended meeting of U. S. L. S. S. Association at Chicago, representing Michigan.

December 14.—Found outbreak of bloody dysentery in dairy cattle at Whittaker. Probably due to filthy water from well in pig pen. Dairy and Food Commission caused alterations to be made.

December 30.—Investigated cause of deaths in sheep at Romeo. Sheep had suffered from stomach worms in fall, gone into winter quarters in bad shape and were very badly infested with sheep ticks. They were sheared and improvement followed.

January 8, 1912.—A suspected case of glanders at Shelbyville was found to be an old horse suffering from a diseased molar.

January 31.—Tested 4 herds near Overisel. Two gave no reactions, in one 100 per cent reacted, and in the other only one steer calf failed to react. These animals were supplying milk to the Overisel Creamery. Skim milk from this creamery is returned unsterilized to the community at large. The reacting cattle were shipped to Detroit and slaughtered under federal inspection.

February 10.—An investigation was made at Flint of a disease of pigs. A certain bunch of pigs was dying on this farm although hog cholera serum had been used on the entire herd. The pigs that died showed a purulent broncho-pneumonia and pericarditis. They had been introduced on to this place during extremely cold weather and acute congestion of the lungs was undoubtedly present at the time of treat-

ment. This trouble persisted perhaps on account of the development of a germ of unusual pathogenicity.

March 5.—Tested over 90 cattle at Traverse City asylum. Large number reacted. Reacters shipped to Detroit and killed under federal inspection.

March 13.—Found hog cholera at Freesoil. Origin not determinable.

March 14.—Retested herd of 11 cattle at Comstock Park. These cattle were all tuberculous as determined at autopsy. Four failed to react typically.

March 21.—Tested herd at Litchfield. One reacted. Quarantined.

April 1.—Tested 60 cattle at Ionia Asylum for Criminal Insane. No reacters.

April 4.—Tested 40 cattle near Grand Rapids on farm of Mr. McN———. Three reacted.

April 10.—Found stomach worms in sheep at Turner.

April 11.—Investigated outbreak of influenza in horses at Saginaw. Horses had been shipped in from Chicago and a number had died. Disease did not spread seriously.

April 13.—Tested horse of Mr. J——— G———, Portland, with mallein. Typical reaction. This horse had already reacted to agglutination and complement fixation tests. The animal was slaughtered at the bacteriological laboratory and glanders nodules were found in the lungs, liver and spleen. The nasal septum and maxillary sinuses were affected unilaterally. Thirteen samples of blood were drawn from horses and mules. No reactions.

April 18.—Tested 4 herds near Overisel. In the first herd 2 reactions, in second 1 reaction, in third 1 reaction, and over 60 per cent in last herd. All reacters shipped to Detroit and slaughtered under federal inspection.

April 25.—Tested herd near Adrian. No reactions.

April 27.—Tested large herd at Palmyra. Two reactions.

May 9.—Tested herd at Bay City. About 60 per cent reacted.

May 17.—Found cattle dying on farm near Grand Blanc. Autopsy on one calf showed intestinal hemorrhage in caecum and colon near ileo-caecal valve. No cause could be found.

May 23.—Rabies at Byron. Three cattle bitten. One only died.

May 24.—Inspected herd near Lansing reported by Dairy and Food Department. Later, test made by Mr. Himmelberger. Showed no reactions.

May 27.—Found 5 farms near Durand on which hog cholera had been raging. Serum was not used. Too late.

May 28.—At Lowell, found stomach worms (H. contortus) in calves. Five had died. First time seen by us in Michigan in calves. Pasture was low and wet.

May 31.—Tested herd at state institution at Lapeer. One reaction.

June 1.—Killed cow tested for Altenheim October 13, 1911. No lesions were found.

June 4.—Treated by simultaneous method show herd of Berkshires at Bennington. This was an effort to establish a plan for treatment of show stock in order to insure protection throughout the fall fair circuit.

June 5.—Tested herd of Mr. J——— L——— near Zeeland. One reaction.

June 7.—Cow reported as suspicious of tuberculosis at Decatur. Nothing especially suspicious found.

June 8.—Found herd of 90 sheep, western and native, badly affected with scab. Stomach worms also present.

June 14.—At Bellaire cattle had died, probably on account of so-called Grand Traverse disease.

June 18.—Two cattle were autopsied near Flint. One other had died. Symptoms were such as to suggest rabies. Autopsy showed subepicardial, endocardial and pericardial hemorrhages and acute nephritis. No Negri bodies found in cornu ammonis. Diagnosis not made.

June 21.—Tested herd of Mr. J——— H——— near Overisel. Eight tested, of which 5 reacted.

WARD GILTNER.

Dr. van Suchtelen has been busily engaged during the past year endeavoring to find a basis upon which to construct his microbial investigations. His attitude may be presented best in his own language:

"As the successor of Mr. Wentworth, I am continuing his work regarding various widely different soils in relation to their bacterial flora. From the few preliminary results, one may conclude that the influence of frost upon the total number of soil bacteria is not as decisive as was formerly supposed.

In connection with my former work, I have endeavored to find an economical quotient for a momentary condition of the organic compounds in soil. Conformable to its nature, such a numerical expression can only represent a maximum value. However, it is the writer's belief that this quotient might possibly add to the amplification of the agrogeological valuation of the soil.

As a disturbing factor was perceived both in relation to accuracy and significance, the deficiency of the present methods for the determination of those conditions, which we know empirically, influence the Mikroflora in soil most profoundly.

A priori one can scarcely assume that the present methods which have originated from other inner necessities, and therefore must have unavoidably a different scope and purpose, could have the same significance in other spheres with different demands.

It has been necessary for this reason to submit these different methods to an extensive critical consideration. Since from previous experiments, it was made probable that the instantaneous microbiological condition of a soil differs quite markedly in two adjoining places, so it is evident that for soil bacteriological purposes only a modification of the present customary methods of soil investigation has to be applied, a modification of which not the entire field but the individual sample must be necessarily regarded as the unit.

The investigations of the flora of two extreme soil types, peat and sand, begun by Mr. Wentworth in 1910, have been continued. The data allow no definite conclusions, but it may be stated that the influence of frost upon the bacteria was not as decided as other investigators found in other soil types.

A method is at present being worked out to determine the general rate of decomposition of organic matter in soils. Though the results would represent only approximately the maximum values, such data might help in the classification of soils. This work is greatly handicapped by a lack of reliable and accurate methods determining the soil properties essential for bacterial development. This insufficiency is now generally admitted by bacteriologists, because the present methods do not fill the demands of the bacteriologist. It has been necessary, for this reason, to submit these methods to a critical examination. Since previous experiments have demonstrated great variation in parallel soil samples from the same field, it is evident that the present methods of taking average samples have to be modified. The soil sample must remain undisturbed, and each sample must be regarded as a unit."

The work of Mr. Brown is described by himself as follows:

Butter Investigations.—The work with the keeping qualities of butter is still being pursued. As it is known that changes in the casein and in the fat of butter during storage is brought about by factors, presumably microörganisms, the behavior of the microörganisms most commonly found in butter toward butter constituents is now being studied.

Bact. lactis acidi.—The work with *Bact. lactis acidi*, the almost omnipresent milk microörganisms, which has been carried on during the past year has not, as yet, reached the stage where it is ready for publication, but some interesting and valuable results have been obtained.

Concerning the above work and reports, it is unnecessary for me to speak (they speak for themselves). I should be derelict in my duty, however, to close my report without especially noting the diligence, faithfulness, efficiency and loyalty, through deeds, of the individuals who have furnished the foregoing material. My own appreciation of their association, in most cases through several years, is too keen for mere expression.

Very respectfully,
CHARLES E. MARSHALL,
Bacteriologist.

East Lansing, June 30, 1912.

REPORT OF THE CHEMIST.

Director R. S. Shaw:

Dear Sir—I herewith submit the following report from the Chemical division for the year ending June 30, 1912.

Mr. Wm. C. Marti, a graduate of the University of Illinois, was engaged to fill the vacancy caused by the resignation of Mr. O. B. Winter, and he began his duties September 1, 1911. Mr. Arao Itano, a graduate of Michigan Agricultural College, was appointed to fill the vacancy caused by the resignation of Mr. Clarence Clippert.

The investigations originated under the Adams fund are still in progress, and it is gratifying to report that the results thus far obtained

by Mr. Robinson from pot experiments, started two years ago in conjunction with his laboratory studies, have given valuable information along, at least, two lines. Analyses of the drainage waters, have thrown a considerable light upon the removal of the inorganic salts or mineral plant food compounds from soils under different conditions. Some information which will prove of value in regard to the use of peat as a re-enforcement of manure has also been obtained. The manuscript for a bulletin embodying these results is now in preparation.

Further studies have been carried on with the electrical conductivity method of preparing neutral ammonium citrate solution and an abbreviated paper on the subject was recently published in the Journal of Industrial and Engineering Chemistry. A short paper on the subject was also presented before the Association of Official Agricultural Chemists and it is worthy of mention that a resolution was adopted at that meeting calling for co-operative work upon the method looking toward its adoption by the association, as a provisional method. A manuscript, outlining the method in detail and giving some results obtained, is submitted herewith for publication in this report as Technical Bulletin No. 12.

The co-operative work with the Horticultural division upon the use of cover crops and fertilizers for grapes is demanding more and more attention from the grape growers of the state and already several of the growers in the vicinity of Lawton are adopting the practice as a direct result of these experiments.

The fertilizer control work is still on the increase. During the past seven years there has been a gain of 122 per cent in the number of brands of fertilizer licensed for sale, with a gain this year of 16 per cent over the season of 1911. This large increase in the number of brands necessarily means a big increase in the analytical work and with our present laboratory force, available for this work, four months at least are required to complete analyses.

Many requests are made upon the division for information and advice in regard to the use of commercial fertilizers in general farm practice. Since no carefully planned experiments along this line have been conducted by the Station there is no available data upon which to give information, consequently advice of a very general character only can be given and the person seeking information is usually urged to experiment for himself. In a few cases, upon request, plans of experiment have been suggested. One such experiment is being conducted by the Fremont Canning Company, to find out what combination of fertilizers is best adapted to conditions in that section. The experiment was started during the spring of 1912 but excessive rains when the crops were young will prevent drawing any conclusions this year.

Sixty samples of miscellaneous materials have been analyzed for residents of the state during the year. Among them were several samples of linseed oil, 50 per cent of which were found to be adulterated.

In conclusion I wish to record my hearty appreciation of the efficient and careful work of my associates to whom credit for much that the division has accomplished is due.

Very respectfully,
ANDREW J. PATTEN,
Chemist.

East Lansing, June 30, 1912.

REPORT OF FARM CROPS EXPERIMENTER.

Director R. S. Shaw:

Dear Sir—I wish to submit the following report of the Division of Farm Crops for the year ending June 30, 1912.

SOIL FERTILITY EXPERIMENTS.

The soil fertility and rotation of crops experiments started in 1911 have been continued as originally planned. While the unfavorable weather conditions the past season have resulted in some cases in an unsatisfactory stand of clover and a rather poor stand and growth of some of the other crops, this condition is not more serious than should be expected occasionally in a long continued experiment of this nature and not more serious than experienced on the average farm of the state. These experiments have not progressed far enough as yet to yield any very pronounced results.

CROP IMPROVEMENT.

The crop improvement work has been continued along the same lines as formerly and on about the same scale. Mr. F. A. Spragg, who has had immediate charge of the work, reports the following in regard to development of this work: "Those who have followed the work of crop improvement on the Experiment Station know that a large number of pure lines of wheat, oats and barley have been tested for quality and yield. Thousands of individual plants of clover, alfalfa, timothy, beans and soy beans have also been handled in this work. The most outstanding fact in connection with this year's work is that the winter of 1911-12 was extremely unfavorable for the development of a good crop of wheat. The fall was wet and cold, causing the fall seeding of grain to make a slow growth and to be poorly developed when winter set in. The ground was wet when it froze and during the winter we had a long period below zero, which was as much as 25° and 30° below zero at times. While the severe winter has resulted in a very thin stand and poor crop, it has enabled us to discard some of the less hardy varieties of wheat and winter barley. The varieties of winter rye have survived in good condition.

On the basis of yield, quality and winter hardiness, several varieties of wheat were selected as superior to all others. Among these several wheats, between 3,000 and 4,000 flowers were hybridized during June, 1911. This was done in the hope that we may be able to combine the desired qualities of several wheats in one.

In the clover and alfalfa work there has also been a high percentage of winter killing but as there are a few plants in most of the selections which have survived the winter, it furnishes the means of developing more hardy strains.

The work of breeding the spring grains is progressing along the same lines as formerly. The varieties of spring barley show the best appear-

ance of any of our tests thus far. Numerous strains of oats have again been dropped and new ones are being tested in the hope that they may prove to be of value for distribution or as foundation stocks in our breeding work."

EXTENSION WORK.

The testing of the improved varieties of wheat and oats developed by the Experiment Station and the testing of the varieties of corn from some of the best corn growers in the state have been continued in much the same way as in previous years with the exception that this work has practically been limited to the membership of the Michigan Experiment Association with the idea of securing more reliable co-operators and the forming of a closer affiliation between the co-operators and the college. This work has also included in a smaller way the testing of improved strains of alfalfa, clover, field beans and soy beans. Many of these experiments have been visited by the field agent or other representative of the department. While the severe winter conditions have caused the winter killing of some of the wheat and other unfavorable conditions have resulted in only a fair development in some of the other crops, it may be said that the tests show a fair comparison between the several varieties and that on the whole the college seeds are proving to be considerably better than the home varieties grown by the cooperators.

In several instances larger quantities of wheat and oats than formerly sent out, have been distributed, so that several of our co-operators will have seed for sale during the coming season thus making a beginning towards the furnishing of an adequate supply of seed of the improved varieties to meet the demands of the state.

The extension of alfalfa growing by the organization of alfalfa clubs, as outlined in the Board of Agriculture Report for 1911, has made satisfactory progress. The total number of clubs organized to date not including those in the Upper Peninsula, which have been placed under the supervision of the Upper Peninsula Field Agent, is 69. These have all been visited by the Farm Crops Field Agent, most of them for the second time. Of those visited for the second time nearly all the members, following the directions of the college, have been successful in securing at least, a fair stand and growth of alfalfa. The success with which these seedings have been made and also the reports received from other sources, indicate that this crop is coming to be highly prized among the farmers of the state and that the acreage devoted to it is rapidly on the increase.

While the above activities, as well as other phases of extension work, which cannot be discussed here, have progressed satisfactorily, another important field of work has been almost entirely neglected for lack of sufficient help to carry it on. I refer to a careful study of the production of the more important crops of the state in those sections where these crops are most promising and the issuing of popular bulletins on the same. While a limited amount of work is being done in most of these crops at the Experiment Station, it is essential on account of the variable conditions throughout the state that this work be extended to various sections.

Field beans for instance, is a very important and a staple crop throughout much of the southern part of the state, but practically no investigation has been made in this or other states in connection with the growing of this crop. The study of the bean blight alone is an important and especially inviting field for study, as this disease is causing thousands of dollars of damage to the bean industry of the state annually and practically nothing is being done to control it.

Other crops that should be studied are sugar beets, field peas, vetch and clover as well as numerous other crops. It is hoped that well trained men may soon be available for taking up work of this nature with some of the more important of these crops.

Respectfully submitted,
V. M. SHOESMITH,
Farm Crop Experimentalist.

East Lansing, June 30, 1912.

REPORT OF THE SOIL PHYSICIST.

Director R. S. Shaw, College:

Dear Sir—The year just closing has been marked by gratifying results.

On June 20, 1911, Mr. George J. Bouyoucos entered upon his duties as research assistant in this department. The work as previously planned was along the line of the *functioning of soils as regards heat and temperature.* The behavior of soils along these lines in practice does not seem to accord with previous supposedly established theory; while in many cases both theory and knowledge are lacking.

During the year a goodly amount of work has been done, and the data secured will add considerably to our knowledge and understanding of soils. A fuller report of the work will later be ready in the form of a bulletin, the manuscript of which is now in process of preparation.

Two basement rooms in the Agricultural Building, especially adapted to our needs for this investigation work, have been converted into laboratories. One of these rooms is so located as to possess a relatively constant temperature which makes it ideal for our work.

Out-of-door work is also in operation, a fuller description of which will appear later in another form.

Some co-operative work is being carried on in attempting to increase the productiveness of certain worn-out soils. The results are gratifying. Visits have also been made to certain farms with a view to offering advice in the way of soil management.

Respectfully submitted,
JOS. A. JEFFERY,
Soil Physicist.

East Lansing, June 30, 1912.

REPORT OF THE BOTANIST.

Director R. S. Shaw:

Dear Sir—I submit herewith the following report of the work of the Botanical division for the year ending June 30, 1912.

During the course of the past year, Dr. William H. Brown, Research Assistant in Plant Physiology, resigned to take effect September 1, 1911, having accepted a position in the Bureau of Science at Manila, P. I. His place was filled by Dr. R. P. Hibbard, previously Botanist of the Mississippi Experiment Station. This change, of necessity, interrupted the work in plant physiology quite seriously but at present Dr. Hibbard is very actively engaged in carrying on some very interesting experiments which promise to be of great ultimate value.

Professor Coons has been working on a certain type of apple canker for his special topic but has been getting in touch with the plant disease situation in all parts of the state, so far as possible. For this purpose, he has made a number of trips into different regions.

The equipment of the Botanical division has been very decidedly added to by the purchase of three pieces of Freas Constant Temperature apparatus, namely, drying oven, digester and water bath, in addition to various electrical apparatus necessary in the study of solutions. Numerous books of value in the study of plant diseases and plant physiology have been obtained from the Experiment Station library fund as well as a few by direct purchase.

It has been necessary for the Botanical division to overflow into the hallway to place some of its apparatus and supplies, as well as to have certain of the apparatus placed in the basement and the botanical greenhouse.

Examination of seed samples in accordance with the provisions of the Pure Seed Law, has been carried on in the past year as in the previous year, under the immediate supervision of Mr. Mancel T. Munn, who, upon his graduation, accepted a position in the N. Y. Experiment Station at Geneva, where he will have charge of the seed work. A bulletin on the results of the seed examinations last year and this year is in preparation.

Respectfully submitted,
ERNST A. BESSEY,
Botanist.

East Lansing, June 30, 1912.

REPORT OF THE ENTOMOLOGIST.

Director R. S. Shaw:

Dear Sir—Following is a brief report of the work of the Division of Entomology for the year ending June 30, 1912.

The season thus far has been rather an exceptional one, from the standpoint of the entomologist. The cold, wet spring has brought on very serious outbreaks of cut-worms and plant-lice. The reason being that the cold weather in early spring has held back the parasites that ordinarily hold these insects in check and the pests themselves obtained such a start that it is likely to last all summer. All sorts of plant-lice are very abundant, but worse than the rest, perhaps, is the rosy plant-louse of the apple. This pest does not migrate to any extent during the summer and its effect on the apple crop is likely to be serious.

As usual, a number of unknown pests have been sent in and so far as possible, these have been bred and their identity determined. The correspondence constantly grows in volume, and replies to queries concerning pests consume more and more time every year.

During the year a revised edition of the Spray and Practice Outline was prepared by Professor Eustace and the writer, and published as Special Bulletin No. 57.

Dr. G. D. Shafer is still working on some problems concerning how contact insecticides kill insects and he expects to prepare another bulletin on the subject in the near future.

The experiment started last year in the attempt to introduce the European parasites of the Tamarack saw-fly, is still in progress, but the exceptionally hard winter just passed has no doubt killed off many of the friendly insects. We think, however, that some came through successfully.

A new pest, which curls the tips of the box-elders and buckeyes has appeared and several complaints have been received from the cities where parks are maintained. It is being studied and no doubt control measures will be discovered.

A trip was made in June to Boston and New Haven in order to study the brown-tail and gipsy moths as well as the leopard-moth and the elm-leaf beetle, and to see in operation the methods in use for their control, since it is unlikely that our state will long escape some one of these pests.

Respectfully submitted,

R. H. PETTIT,
Entomologist,

East Lansing, June 30, 1912.

REPORT OF THE HORTICULTURIST.

Director R. S. Shaw:

Sir—I herewith submit a report of the Horticultural division of the Experiment Station.

The tests of the desirability and value of different cover crops in vineyards and orchards have been continued as in the past two seasons, this year, in three vineyards near Lawton and in orchards at South Haven, Ludington, Scottdale, Bellaire and Hart. Where the land is plowed, the winter vetch has given the best satisfaction. It is sown during the first part of August, using 15 to 30 pounds of seed per acre and by adding a bushel of oats, a quick growth or catch crop can be secured. A bushel or a half bushel of rye is sometimes used in place of the oats. Some fruit growers prefer to work the soil in their orchard by discing instead of plowing and prefer a cover crop plant that is killed by the winter so that it can be worked into the soil easily. An excellent combination is a bushel of oats and a bushel of Canada peas.

A circular giving our experience with various cover crops will be issued this summer.

The practice of spraying potatoes with Bordeaux mixture has continued to be a paying operation even when the blight (Phytophthora infestens) was not present. Last fall there was a gain of 39 bushels per acre for four sprayings. Potato growers of the state should be alive to the advantages of spraying as a factor in increasing crop production. Nearly all fields have to be sprayed once or twice with poison for bugs. The expense of the Bordeaux which could be applied with the poison would be small, probably no operation in connection with the production of the potato crop would pay as well nor could be done with so little extra labor as making a few sprayings.

Tests with various fertilizers have been continued and we have, from our experience, suggested 500 pounds per acre of a home mixed formula given in Circular No. 15, issued in April, 1912, to which the reader is referred.

A few years ago, there was a belief common among some fruit growers that the long time required by apple trees before bearing might be due to using scions of "water sprout" or "sucker" or "non-bearing" wood instead of scions from fruiting trees or the portion of a tree that was fruiting.

An experiment to test this question was started in 1909 by securing "blind" or "sucker" wood and "fruiting" wood and grafting the scions on Paradise roots. Some of the varieties have now fruited and there does not seem to be any difference due to the different kinds of wood.

The experiments to determine the difference in cherry trees growing on different stocks is progressing nicely, but at this time there is no indication of any marked difference in either kind of stock.

Report of progress can also be made on the value of the different fertilizers for young trees.

Orchard spraying experiments have been carried on at Hart and

South Haven to determine the comparative value of Bordeaux mixture, self-boiled lime-sulphur and commercial lime-sulphur. The indications were that the commercial lime-sulphur could be used with safety on cherries and European plums. It does not appear to be safe upon Japan plums nor peaches.

The other horticultural experiments have not progressed far enough to make any report upon.

Respectfully submitted,
H. J. EUSTACE,
Horticulturist.

East Lansing, June 30, 1912.

ANNUAL REPORT OF THE SOUTH HAVEN EXPERIMENT STATION.

H. J. Eustace, Horticulturist:

Dear Sir—The following report upon the work of the South Haven Sub-station is herewith submitted.

The past year was one of large crops of all kinds of fruits. There were more varieties in bearing than for many years before, and a few new varieties that bore for the first time.

The entire fruit crop was very free from fungous diseases and insects.

PROMISING VARIETIES.

The following varieties of apples have done well for the past few years and they are not commonly grown in Michigan:

Akin.	Fameuse Sucre.
Black Annette.	Duchess Seedling.
Dudley.	Evans.
Gloege.	Horse.
Hamilton Black.	Indian.
Magyer.	Milwaukee.
Newby.	No. 1 New.
Pease (Walter).	Oxford Orange.
Traveler.	Star.
Sweet Orange.	Spencer.
Springdale.	Winter Banana.

Gloege, Horse, Magyer and Indian are very productive but not of very high quality.

Akin and Fameuse Sucre are of very good quality and bear well but are only medium in size. Fameuse Sucre being of the Snow type is susceptible to scab.

Black Annette, Duchess Seedling, Hamilton Black, Milwaukee, Newby, No. 1 New, Pease, Oxford Orange and Springdale are of fair quality and bear moderately good crops.

Sweet Orange ripens about the time of the Tolman. It is very productive but not as good for baking as the Tolman.

Spencer is a large apple of the Northern Spy type. The tree comes into bearing earlier and the fruit ripens earlier than the Spy. The quality is good.

Traveler and Star are two new varieties that have just come into bearing. The trees bear early and are productive. Neither is of very high quality. Both are greenish yellow apples with a red cheek. Star ripens in the late fall and Traveler is a winter variety.

At the Sub-station, the Winter Banana continues to be a very desirable variety. The tree bears early and regularly. The fruit is a little irregular in size and somewhat susceptible to apple scab.

PEACHES.

In a young orchard, planted since the freeze in October, 1906, the Sea Eagle, Judd and Billmyer seem to be already especially promising. The Sea Eagle is the first yellow flesh peach of good quality that is a good shipper, to ripen in this orchard. It is of medium size and well splashed with red; it ripens early in August. The Judd and the Billmyer are yellow flesh peaches of good quality and appearance. Both ripen the first week in September.

Mayflower is the first peach to ripen. It is a white cling peach. The skin is well striped and splashed with red. Its appearance is good but the quality is poor. Earliness is its greatest feature; it ripens about the middle of July.

SMALL FRUITS.

The Portage gooseberry and the Perfection currant continue to be very valuable and are worthy of a trial by the small fruit growers.

The Austin dewberry has proven of value.

The Rathbun blackberry and the Plum Farmer are both very promising varieties.

We have no new varieties of red raspberries that are at all promising and the same can be reported regarding cherries, plums, pears and grapes.

EXPERIMENTS.

During 1911 we conducted a comparative test of the effects of Bordeaux mixture, commercial lime-sulphur and self-boiled lime-sulphur in the apple and peach orchards of Mr. C. J. Monroe of South Haven.

The apples were all Wageners and the sprayings were made at the times generally recommended for spraying apples. The peaches were not all the same variety but were all standard varieties. The formulas used were for the commercial lime-sulphur 1 to 50; self-boiled lime-sulphur 8 pounds of lime, 8 pounds of sulphur to 50 gallons of water and of the Bordeaux, 3 pounds of copper sulphate and 5 pounds of lime to 50 gallons of water. Poison was added to these spraying materials as required.

Since there were so few diseases, the greatest differences noted were in the general appearance and color of the fruit and foliage in the apple orchard. The trees sprayed with the commercial lime-sulphur produced

fruit that was better color and smoother than trees sprayed with the self-boiled lime-sulphur, or the Bordeaux, while the color of the fruit sprayed with the self-boiled lime-sulphur was not as bright as where the spraying was done with the commercial lime-sulphur. Trees sprayed with Bordeaux mixture had a very good color on the foliage but not as bright a color on the fruit. In experiments on peaches, the Bordeaux mixture invariably burned the foliage, producing an effect much as the shot hole fungus does. The commercial lime-sulphur burned the leaves slightly and the foliage on trees that were sprayed with the self-boiled was not injured at all. Owing to the dryness of the season, we were unable to get any definite results on the rot or other fungous troubles. The amount of this was so small in all parts of the orchard, that no conclusions could be drawn.

The method of applying this spraying mixture is undoubtedly an important factor in relation to the burning of the foliage. Where coarse nozzles are used and trees are drenched, there is nearly always injury done to the foliage and it seems highly desirable to use new fine nozzles and make a light spraying.

Respectfully submitted,

F. A. WILKIN,

Superintendent.

South Haven, June 30, 1912.

BULLETINS

OF THE

AGRICULTURAL COLLEGE EXPERIMENT STATION

ISSUED DURING THE

YEAR ENDING JUNE 30, 1912.

FERTILIZER ANALYSES.

Bulletin No. 265.

ANDREW J. PATTEN, O. B. WINTER AND C. G. CLIPPERT.

SUMMARY OF FERTILIZER LAW.

The inspection and analyses of the commercial fertilizers offered for sale in Michigan are made under authority of an act of the Legislature, approved March 10, 1885. The full text of the law has been printed in former bulletins, and its salient points alone will be referred to here. It provides that all commercial fertilizers, retailing for more than ten dollars per ton, shall be accompanied by a statement certifying the number of net pounds in the given sack, the brand, name and address of the manufacturer, and a chemical analysis stating the percentages of nitrogen, of potash soluble in water, of available (soluble and reverted) phosphoric acid, and the insoluble phosphoric acid. (Sec. 1.) It provides that the manufacturer, importer or agent (the latter only in case the manufacturer fails to comply with the law), shall pay annually a license fee of twenty dollars for each brand offered for sale. (Sec. 3.) It provides that any person offering unguaranteed or over-guaranteed goods, shall be subject to a fine. (Sec. 6.) The full text will be furnished on application.

LICENSED BRANDS.

Twenty-seven manufacturers and fertilizer companies have licensed 230 distinct brands for sale in the state during the season of 1911. The brands appearing in the following tables of analyses, and no others, can be legally sold.

Parties manufacturing or importing fertilizers for their own use and not for sale are not affected by the restrictions of the law.

COLLECTION OF SAMPLES.

The sampling agents of the Station, during the months of April, May and June, drew 410 samples from dealers' stocks representing 178 different brands. The failure to get samples of 52 brands is due to the fact that many of them are sold only in the fall, then, too, a few companies sell direct to the consumer through the Grange and other organizations

and consequently it is only by chance that samples of such goods are obtained. If persons ordering goods in this way wish to have them inspected they will protect themselves and at the same time confer a favor on this department by notifying us, and upon the arrival of the goods an inspector will be sent to draw samples.

It is the desire of this department to make the inspection as complete as possible, and any information to further this end, from dealer or consumer, will be greatly appreciated. In all cases of failure to find a brand on the market, the analysis was made on the manufacturer's sample as indicated in the tables of analyses.

RESULTS OF INSPECTION.

A study of the tables of analyses shows that, of the 249 samples analyzed, representing 230 brands, 26 (10%) are below guarantee* in one or more constituents. Fourteen (5.6%) are below guarantee in nitrogen, 4 (1.6%) are below guarantee in available phosphoric acid, 2 (0.8%) are below guarantee in total phosphoric acid and 15 (6%) are below guarantee in potash. Six (2.4) are below guarantee in nitrogen and potash, 1 (0.5%) in nitrogen and available phosphoric acid.

While there are, as stated above, 34 samples falling below guarantee in one or more constituents, there are, however, only 3 (1.2%) that are more than 75 cents per ton below their guaranteed commercial value. That is, the shortage in one constituent is compensated by an excess of the guarantees in the other constituents. This is a very satisfactory showing.

SCHEDULE OF TRADE VALUES.

In accordance with the custom adopted and followed in previous years, the following schedule of prices for determining the commercial valuation of a fertilizer is published:

Nitrogen	16½c per pound
Potash soluble in water	4½c " "
Available phosphoric acid	5c " "
Total phosphoric acid in bone	4c " "
Insoluble phosphoric acid in fertilizers containing nitrogen	2c " "

In fertilizers containing no nitrogen no value is given to insoluble phosphoric acid. The valuation of a fertilizer is determined as follows: The percentage or pounds per hundred of each ingredient (nitrogen, available phosphoric acid, insoluble phosphoric acid and potash) is multiplied by 20, giving the number of pounds of each ingredient in a ton. These figures are then multiplied by their respective pound prices.

In the last column of the table of analyses headed "Valuation" is given the commercial valuation of the samples, as guaranteed and as found, based upon the prices quoted above.

*A shortage of more than 0.10 per cent of nitrogen of more than 0.20 per cent of available phosphoric acid or potash is considered below guarantee.

In calculating the valuations we have assumed that the sources of the various ingredients have been the same in all cases, which of course is not true and also unfair to the manufacturer using only high grade goods, as it places the manufacturer who uses low grade materials, on the same level.

However, it should be clearly understood that the station valuation does not represent the proper retail price of the fertilizer at the point of consumption. It does represent the cash cost, at the larger fertilizer centers of the middle west, of an amount of nitrogen, available phosphoric acid and potash in unmixed, standard raw materials of good quality, corresponding with the amounts found in one ton of the fertilizer in question.

The difference between the selling price and valuation is represented by the cost of storing, grinding, bagging, hauling and freighting the goods, commissions to agents and dealers, bad debts, depreciation of machinery, interest on investment, etc. The percentage of difference between the valuation and selling price should not be more than 35 or 40.

Commercial valuations are useful, to show whether a fertilizer is worth its guaranteed money value. Purchasers will often find them useful in comparing the relative values of similar brands offered by different manufacturers.

The commercial valuation bears no relation to the agricultural value of a fertilizer, this is measured only by the increased yield of crop due to its use.

The mixing of the ingredients of which a fertilizer is composed does not increase their crop-producing power. They would produce the same effect if applied separately. The mixing simply lessens the labor of applying the materials.

Following are the names of the parties from whose stocks samples were drawn:

Adrian—Cutler, Dickerson & Co., W. R. Bradish, C. C. VanDoren, J. E. Bennet.

Alma— ———— Montigle.

Armada—C. I. Stump.

Azalia——Calvin Critchett, A. D. Master.

Battle Creek—Robert Binder, J. E. Moon, Caldwell & Armstrong.

Bankers—Wm. Cole.

Bay City—Bay County Hardware & Implement Co., Mohr Hardware Co., Jennison Hardware Co., Presley & Layer, R. C. Bialy, F. C. Goodeyne.

Belleville—Stephen Pearl.

Benton Harbor—B. M. Nowlen & Co., Cutler & Downing.

Birmingham—H. B. Parks.

Blissfield—M. Wolverton.

Bridgman—Bridgman Supply Co.

Brown City—John H. Linck.

Charlotte—R. J. Garber & Son, L. H. Shephard Milling Co.

Clayton—E. H. Hutchins.

Coldwater—A. J. Fiske, S. I. Treat & Son.
Coloma—J. T. Vanderveer, Wm. Stratton, Rube Hazen, E. M. Jackson.
Coopersville—Lang Bros., Reynolds Bros.
Covert—J. R. Spelman & Co.
Dearborn—C. Kandt.
Elm—I. Wilson, Shaw Bros.
Fremont—Dirk Kolk.
Galien—F. A. Koenigshof, Roberts Bros.
Grand Haven—Speidel & Swartz.
Grand Rapids—Jones Seed Co., Brown Seed Co., Grand Rapids Glue Co.
Harbert—Alexander Knaute.
Hillsdale—G. A. Aldrich & Son, C. H. Burlingame & Co., Wm. French, Newton Gregg, C. Dauber.
Holland—Mulder & Lugas, Klaas Dykhuis, John Meeswesner, Albert Alferink, Henry Siersma, H. W. Harrington, Groenewoud & Devries.
Hudson—W. H. Rhead, J. A. Dillon Jr., Atherton & Garling.
Ida—N. A. Weipert, Ida Hardware Co.
Ithaca—Isbell Seed Co., Jas. Boland Fert. Co., Watts, Morehouse Co.
Kalamazoo—M. DeWitte.
Lansing—Chas. G. Longstreet.
Lawton—Michigan Fruit Exchange.
Lennon—Ambert Weller.
Lenox—B. J. Reichman.
Lulu—Schultz Bros.
Manchester—Adam G. Houch.
Mason—J. E. Bullen, R. J. Osborne.
Maybee—M. L. Blanch, Fred Smith.
Memphis—Day & McCall.
Midland—Midland Milling Co., C. G. Olmstead.
Milan—Forsythe Co.
Monroe—Geckle & Martin.
Mt. Clemens—John N. Tucker.
Muskegon—John Steginly.
New Boston—R. E. Krause.
New Buffalo—Seigmund Bros.
Niles—E. E. Woodford.
Nunica—E. W. Hass, J. D. Pickett.
Owosso—A. B. Cook, Owosso Sugar Co., C. C. Wright, L. C. Hall.
Palmyra—P. P. Cook.
Petersburg—H. A. Logan & Son, T. Kohler.
Plymouth—C. F. Smith, G. C. Raviler, J. McLain, W. S. Burch, J. C. O'Bryan.
Quincy—Wm. A. Lott, J. N. Boyer.
Reading—Rigleman Bros., Arthur L. Lane, W. C. Hale, Walter Crawford.
Redford—C. A. Lasher, Westlake Bros.
Saginaw—Henry W. Carr Co.
Salzburg—Geo. L. Frank.
St. Louis—St. Louis Hardware Co.
South Haven—Merrifield & Brown.

Strasburg—C. W. Rau, J. F. Meyer.
Tecumseh—Slayton & Son.
Three Oaks—Chas. F. Bachman, J. W. Smith.
Waltz—Ludwig Krzszke, A. Ziegler.
Warren—F. A. Reddick, ——— Wolf.
Willis—George Freeman, R. J. M. King.
Willow—Jesse Butler.
Wyandotte—F. Bush, C. Koch.
Ypsilanti—Martin Dawson.
Zeeland—Isaac VanDyke, Henry Scholten, G. W. Hungerink, R. Knap.

Results of analyses of commercial fertilizers for

Laboratory number.	Trade name.	Locality where sample was taken.	
	American Agricultural Chemical Co., Detroit, Mich.		
2898	Banner Dissolved Bone	Manufacturer's sample	Claimed Found
2723	Beet Fertilizer	W. Bay City	Claimed Found
2680	Double 10 Fertilizer	Bankers	Claimed Found
2850	Fine Ground Bone	Adrian	Claimed Found
2851	High Grade Bone and Potash	Adrian	Claimed Found
2681	High Grade Garden and Vegetable Fertilizer	Charlotte	Claimed Found
2724	Maine Potato Formula	Covert	Claimed Found
2682	M and I Special Manure	Bankers	Claimed Found
2881	M and I Special Manure	Holland	Claimed Found
2882	M and I Special Manure	Adrian	Claimed Found
2952	M and I Special Manure	Brown City	Claimed Found
2828	Michigan 10% Potash Manure	Fremont	Claimed Found
2726	Muriate of Potash	Covert	Claimed Found
2727	Nitrate of Soda	Covert	Claimed Found
2683	New York State Special	Bankers	Claimed Found

1911, expressed in parts per one hundred.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
....	.... 38.00	.... 3.76	34 34.24	....	$34 00 34 24
1.23 1.39	11 11.75	.... 1.64	9 10.11	2 2.16	15 66 17 30
....	12 13.63	.... 1.93	10 11.70	10 10.37	19 00 21 03
2.47 2.89	20 21.32	....	....	....	24 15 26 60
....	12 14.40	.... 2.48	10 11.92	5 5.30	14 50 16.69
1.65 1.82	10 10.55	.... 1.11	8 9.44	5 5.51	18 75 20 85
1.65 1.76	10 10.30	.... 1.04	8 9.26	10 10.58	23 25 25 03
2.47 2.48	10 11.00	.... 1.11	8 9.89	6 6.12	22 35 25 12
2.47 2.50	10 11.80	.... 1.12	8 10.68	6 5.11	22 35 23 98
2.47 2.47	10 11.35	.... 1.20	8 10.15	6 6.63	22 35 24 75
2.47 2.54	10 10.37	.... 1.06	8 9.31	6 6.52	22 35 23 98
0.82 0.94	7 7.40	.... 0.65	5 6.75	10 10.23	17 51 19 32
....	....	....	....	49 50.15	44 10 45 14
15 15.66	....	....	....	....	49 50 51 68
0.82 0.93	10 10.63	.... 0.95	8 9.68	3 3.18	14 21 15 99

Results of analyses of commercial fertilizers for

Laboratory number.	Trade name.	Locality where sample was taken.	
	American Agricultural Chemical Co.—*Con.*		
2725	Special Pea and Truck Fertilizer	Holland	Claimed.... Found......
2728	Bradley's Acid Phosphate	Covert	Claimed.... Found......
2841	Bradley's Alkaline Bone and Potash	Elm	Claimed.... Found......
2729	Bradley's B. D. Sea Fowl Guano	Covert	Claimed.... Found......
2844	Bradley's Dissolved Bone and Potash	Monroe	Claimed.... Found......
2860	Bradley's Niagara Phosphate	Lennox	Claimed.... Found......
2899	Bradley's Soluble Dissolved Bone	Manufacturer's sample	Claimed.... Found......
2900	Bradley's Special Potash Fertilizer	Manufacturer's sample	Claimed.... Found......
2861	Crocker's Ammoniated Wheat and Corn Phosphate	Memphis	Claimed.... Found......
2901	Crocker's Dissolved Bone and Potash	Manufacturer's sample	Claimed.... Found......
2730	Crocker's General Crop Phosphate	W. Bay City	Claimed.... Found......
2684	Crocker's New Rival Ammoniated Superphosphate	Bankers	Claimed.... Found......
2685	Crocker's Universal Grain Grower	Charlotte	Claimed.... Found......
2686	A-1 Potash Fertilizer	Reading	Claimed.... Found......
2733	High Potash Phosphate	St. Louis	Claimed.... Found......

1911, expressed in parts per one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available		
2.47 2.49	11 11.52	.... 1.19	9 10.33	2 2.35	$19 75 21 15
....	12 13.70	.... 2.41	10 11.29	....	10 00 11 29
....	12 13.05	.... 2.18	10 10.87	2 1.99	11 80 12 66
2.06 2.23	10 10.42	.... 1.13	8 9.29	1.50 1.76	16 95 18 68
1.03 1.02	10 10.83	.... 1.04	8 9.79	2 2.02	14 00 15 40
0.82 0.87	9 9.85	.... 0.92	7 8.93	1 1.17	11 41 13 22
....	16 19.30	.... 1.16	14 18.14	....	14 00 18 14
0.82 1.00	10 10.60	.... 0.78	8 9.82	3 3.00	14 21 16 13
2.06 2.14	10 11.10	.... 1.38	8 9.72	1.50 1.72	16 95 18 89
....	12 12.90	.... 2.62	10 10.28	2 1.84	11 80 11 94
0.82 0.97	9 9.52	.... 0.85	7 8.67	1 1.25	11 41 13 34
1.23 1.38	11 11.50	.... 1.54	9 9.96	2 2.21	15 66 18 12
0.82 1.21	10 11.45	.... 1.12	8 10.33	2 2.19	13 31 16 74
0.82 1.02	10 11.42	.... 1.16	8 10.26	3 3.11	14 21 16 89
....	12 13.27	.... 1.76	10 11.51	5 5.12	14 50 16 12

Results of analyses of commercial fertilizers for

Laboratory number.	Trade name.	Locality where sample was taken.	
	American Agricultural Chemical Co.—*Con.*		
2731	Homestead Best Potato Fertilizer	St. Louis	Claimed Found
2687	Homestead Bone Black Fertilizer	Quincy	Claimed Found
2732	Homestead High Grade Garden and Vegetable Fertilizer	Ithaca	Claimed Found
2688	Homestead Pea and Truck Fertilizer	Quincy	Claimed Found
2734	Homestead Special Beet Fertilizer	Holland	Claimed Found
2689	Homestead Sugar Beet Fertilizer	Quincy	Claimed Found
2735	Homestead 10% Potash Manure	Holland	Claimed Found
2690	Homestead Ten—Ten Special Compound	Quincy	Claimed Found
2736	Red Line Complete Manure	Holland	Claimed Found
2902	Red Line Phosphate	Manufacturer's sample	Claimed Found
2842	Red Line Phosphate with Potash	Elm	Claimed Found
2737	Wolverine Phosphate	Holland	Claimed Found
2903	Niagara Dissolved Bone and Potash	Manufacturer's sample	Claimed Found
2738	Niagara Grain and Grass Grower	Salzburg	Claimed Found
2904	Niagara Potato and Vegetable Fertilizer	Manufacturer's sample	Claimed Found

1911, expressed in parts per one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
1.65 1.71	10 10.25	.... 0.94	8 9.31	10 10.13	$23 25 24 45
2.06 2.13	10 11.50	.... 1.16	8 10.34	1.50 1.91	16 95 19 55
1.65 1.73	10 10.17	.... 1.60	8 9.57	5 5.02	18 75 20 44
2.47 2.65	11 12.47	.... 1.12	9 11.35	2 2.56	19 75 22 84
1.65 2.06	10 10.12	.... 0.94	8 9.18	5 5.00	18 75 20 86
1.23 1.45	11 12.50	.... 1.67	9 10.83	2 2.34	15 66 18 39
0.82 1.04	7 6.87	.... 0.86	5 6.01	10 10.56	17 51 19 28
....	12 13.50	.... 1.84	10 11.66	10 10.23	19 00 20 87
0.82 0.94	9 9.65	.... 1.15	7 8.50	1 1.17	11 41 13 11
....	16 19.30	.... 3.06	14 16.24	....	14 00 16 24
....	12 13.86	.... 2.38	10 11.48	2 1.99	11 80 13 27
....	12 13.17	.... 2.32	10 10.85	....	10 00 10 85
....	12 12.85	.... 2.70	10 10.15	2 1.88	11 80 11 84
0.82 0.90	9 9.15	.... 1.02	7 8.13	1 1.10	11 41 12 50
2.06 2.26	10 10.35	.... 1.16	8 9.19	3 3.18	18 30 19 97

Results of analyses of commercial fertilizers for

Laboratory number.	Trade name.	Locality where sample was taken.	
	American Agricultural Chemical Co.—*Con.*		
2905	Niagara Wheat and Corn Producer	Manufacturer's sample	Claimed Found
2739	Horse Shoe Acidulated Bone and Potash	Holland	Claimed Found
2843	Horse Shoe Animal Bone Manure	Wyandotte	Claimed Found
2940	Horse Shoe Bone and Potash	Manufacturer's sample	Claimed Found
2740	Horse Shoe Corn and Wheat Grower	Bay City	Claimed Found
2692	Horse Shoe Garden City Superphosphate	Benton Harbor	Claimed Found
2691	Horse Shoe High Grade Vegetable Fertilizer	Benton Harbor	Claimed Found
2741	Horse Shoe Potash Manure	Ithaca	Claimed Found
2742	Horse Shoe Quick Acting Phosphate	Holland	Claimed Found
2693	Horse Shoe Special Onion and Vegetable Manure	Mason	Claimed Found
2694	Horse Shoe Sugar Beet Fertilizer	Mason	Claimed Found
2906	Horse Shoe 10-5 Potash Manure	Manufacturer's sample	Claimed Found
2695	Horse Shoe 3-8-6 Fertilizer	Mason	Claimed Found
2743	Boar's Head Corn and Wheat Grower	Holland	Claimed Found
2744	Boar's Head Faultless Grain Grower	Holland	Claimed Found

1911, expressed in parts per one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
1.23 1.34	11 11.75	.... 1.46	9 10.29	2 2.05	$15 66 17 14
0.82 0.89	12 13.97	.... 1.67	10 12.30	1 1.42	14 41 17 19
0.82 1.04	9 9.75	.... 1.14	7 8.61	1 1.16	11 41 13 54
....	12 13.65	.... 2.62	10 11.03	2 1.94	11 80 12 78
1.65 1.68	10 11.42	.... 1.22	8 10.20	2 2.29	16 05 18 29
2.06 2.15	10 11.27	.... 0.92	8 10.35	1.50 1.82	16 95 19 45
1.65 1.69	10 10.97	.... 0.81	8 10.16	5 5.29	18 75 20 82
0.82 0.93	10 10.90	.... 0.94	8 9.96	3 3.25	14 21 16 34
....	12 11.62	.... 0.78	10 10.84	....	10 00 10 84
0.82 1.02	7 7.40	.... 0.83	5 6.57	10 10.76	17 51 19 95
1.23 1.47	11 12.40	.... 1.78	9 10.62	2 2.41	15 66 18 35
....	12 13.45	.... 2.48	10 10.97	5 4.92	14 50 15 40
2.47 2.58	10 11.40	.... 1.59	8 9.81	6 6.77	22 35 25 05
1.65 1.71	10 10.65	.... 1.08	8 9.57	2 2.19	16 05 17 61
0.82 1.01	9 9.92	.... 1.02	7 8.90	1 1.87	11 41 14 32

Results of analyses of commercial fertilizers for

Laboratory number.	Trade name.	Locality where sample was taken.	
	American Agricultural Chemical Co.—*Con.*		
2745	Boar's Head High Grade Vegetable Fertilizer	Holland	Claimed Found
2907	Boar's Head Potash Phosphate Fertilizer	Manufacturer's sample	Claimed Found
2746	Boar's Head Soluble Phosphate	Holland	Claimed Found
2747	Boar's Head Sure Growth Potash Manure	Alma	Claimed Found
2748	Boar's Head Sugar Beet Grower	Alma	Claimed Found
2749	Boar's Head 10% Potash Composition	Zeeland	Claimed Found
2750	Boar's Head World of Good Superphosphate	Holland	Claimed Found
	The American Fertilizer Co., Chicago, Ill.		
2696	Union Brand Complete Crop Grower	Three Oaks	Claimed Found
2697	Union Brand Corn and General Crop Grower	Hudson	Claimed Found
2908	Union Brand Dissolved Bone and Potash	Manufacturer's sample	Claimed Found
2751	Union Brand Gardner's Favorite	Bay City	Claimed Found
2883	Union Brand Gardner's Favorite	Tecumseh	Claimed Found
2857	Union Brand High Grade Sugar Beet Grower	Owosso	Claimed Found
2862	Union Brand King's Favorite	Ypsilanti	Claimed Found

1911, expressed in parts per one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
1.65 2.04	10 10.40	.... 1.23	8 9.17	5 5.00	$18 75 20 89
....	12 13.15	.... 2.46	10 10.69	5 4.83	14 50 15 04
....	12 13.92	.... 1.73	10 12.19	....	10 00 12 19
0.82 0.95	10 10.50	.... 0.74	8 9.76	3 3.03	14 21 15 93
1.23 1.39	11 11.82	.... 1.60	9 10.22	2 2.09	15 66 17 33
0.82 0.97	7 7.41	.... 0.67	5 6.74	10 10.11	17 51 19 31
2.06 2.11	10 10.62	.... 0.94	8 9.68	1.50 1.66	16 95 18 51
1.65 1.88	.... 11.25	1.50 1.36	8 9.89	2 2.18	15 84 18 59
0.82 0.89	.... 10.25	1 0.82	8 9.43	4 4.46	14 71 16 71
0.41 0.64	.... 12.25	1 0.94	10 11.31	5 5.43	16 25 18 69
3.20 3.16	.... 11.65	2 0.84	9 10.81	10 9.29	29 36 29 92
3.20 3.07	.... 11.75	2 1.16	9 10.59	10 11.47	29 36 31 50
1.65 1.71	.... 10.10	1.50 1.86	8 8.24	5 6.23	18 54 20 23
0.82 1.01	.... 10.70	1 1.64	8 9.06	3 3.18	13 81 15 91

Results of analyses of commercial fertilizers for

Laboratory number.	Trade name.	Locality where sample was taken.	
	American Fertilizer Co.—*Con.*		
2698	Union Brand Onion, Potato and Vegetable Grower...	Hudson..............	Claimed.... Found......
2849	Union Brand Pure Bone Meal and Potash..........	Tecumseh............	Claimed.... Found......
	Armour Fertilizer Works, Chicago, Ill.		
2699	All Soluble..................................	Galien...............	Claimed.... Found......
2909	Ammoniated Bone with Potash..................	Manufacturer's sample..	Claimed.... Found......
2753	Armour's Bone Meal...........................	Saginaw..............	Claimed.... Found......
2856	Armour's Standard............................	Owosso...............	Claimed.... Found......
2752	Banner Brand.................................	Saginaw..............	Claimed.... Found......
2884	Banner Brand.................................	Nunica...............	Claimed.... Found......
2885	Banner Brand.................................	Midland..............	Claimed.... Found......
2700	Bone, Blood and Potash.......................	Coloma...............	Claimed.... Found......
2893	Bone, Blood and Potash.......................	Saginaw..............	Claimed.... Found......
2894	Bone, Blood and Potash.......................	W. Bay City..........	Claimed.... Found......
2701	Crop Grower..................................	Bridgeman............	Claimed.... Found......
2754	Fruit and Root Crop Special..................	Midland..............	Claimed.... Found......

1911, expressed in parts per one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
1.65 1.68	.... 10.85	1.50 1.51	8 9.34	7 7.96	$20 34 22 64
0.82 1.10	20 20.37	....	....	3 3.01	21 41 22 64
2.88 2.97	.... 9.12	0.50 0.67	8 8.45	4 4.00	21 30 22 12
2.47 2.53	.... 7.50	0.50 0.62	6 6.88	2 2.26	16 15 17 50
1.65 2.09	27 25.30	....	....	....	27 04 27 14
0.82 1.58	.... 11.52	0.50 1.77	8 9.75	3 3.10	13 61 18 46
....	.... 11.17	0.50 0.63	10 10.54	8 8.39	17 20 18 09
....	.... 11.15	0.50 0.25	10 10.90	8 8.08	17 20 18 17
....	.... 11.55	0.50 0.33	10 11.22	8 6.79	17 20 17 33
4.11 4.18	.... 11.78	0.50 3.01	8 8.77	7 7.85	28 06 30.83
4.11 4.27	.... 11.85	0.50 3.48	8 8.37	7 8.37	28 06 31.38
4.11 4.09	.... 12.04	0.50 3.04	8 9.00	7 8.38	28 06 31 25
1.21 1.26	.... 10.47	0.50 1.78	8 8.69	2 2.14	13 99 15 49
1.65 1.66	.... 9.75	0.50 1.17	8 8.58	5 5.14	18 14 19 16

Results of analyses of commercial fertilizers for

Laboratory number.	Trade name.	Locality where sample was taken.	
	Armour Fertilizer Works.—*Con.*		
2755	Grain Grower	Saginaw	Claimed Found
2702	High Grade Potato	Coloma	Claimed Found
2863	Mixed Bone and Potash	Redford	Claimed Found
2910	1-5-10 Fertilizer	Manufacturer's sample	Claimed Found
2756	Phosphate and Potash	Saginaw	Claimed Found
2831	Soluble Phosphate and Potash	Coopersville	Claimed Found
2911	Star Phosphate	Manufacturer's sample	Claimed Found
2757	Sugar Beet Special	W. Bay City	Claimed Found
2703	Wheat, Corn and Oats Special	Battle Creek	Claimed Found
	Bash Fertilizer Co., Fort Wayne, Ind.		
2704	Bashumus Big Crop Producer	Quincy	Claimed Found
2758	Bashumus Big Truck Grower	Lansing	Claimed Found
*2912	Bashumus Corn and Wheat Grower		Claimed Found
2759	Bashumus Corn Special	Lansing	Claimed Found
2760	Bashumus Garden Special	Lansing	Claimed Found

*No sample of this brand was received at the station.

1911, expressed in parts per one hundred.—Con.

Nitrogen.	Phosphoric Acid. Total.	Phosphoric Acid. Insoluble.	Phosphoric Acid. Available.	Potash.	Valuation.
1.65 1.70	.... 9.72	0.50 0.86	8 8.86	2 2.08	$15 44 16 68
1.65 1.68	.... 10.35	0.50 1.14	8 9.21	10 10.78	22 64 24 91
0.82 0.84	18 19.90	....	....	4 4.33	20 71 22 59
0.82 0.76	.... 6.50	0.50 0.80	5 5.70	10 10.51	16 91 17 99
....	.... 11.05	0.50 0.20	10 10.85	2 2.70	11 80 13 28
....	.... 11.50	0.50 0.45	10 11.05	4 4.03	13 60 14 68
....	.... 15.50	0.50 0.22	14 15.28	....	14 00 15 28
0.82 1.07	.... 10.00	0.50 0.71	8 9.29	4 3.95	14 51 16 66
0.82 1.01	.... 8.77	0.50 1.14	7 7.63	1 1.11	10 81 12 42
1.60 **0.97**	.... 9.37	1 0.83	8 8.54	2 **1.73**	15 48 **13 63**
1 **0.84**	.... 10.11	1 0.26	8 9.85	8 **7.39**	18 90 19 37
2	....	1	5	2	13 80 ....
1.20 **0.92**	.... 10.11	1 0.25	8 9.86	4 4.08	15 96 16 67
1 **0.87**	.... 9.36	1 0.33	8 9.03	10 **9.64**	20 70 20 71

Results of analyses of commercial fertilizers for

Laboratory number.	Trade name.	Locality where sample was taken.	
	Robert Binder Est., Battle Creek, Mich.		
2707	Blood and Bone	Battle Creek	Claimed.... Found......
	The James Boland Rendering & Fertilizer Co., Jackson, Mich.		
2705	Blackman General Crop Fertilizer	Jackson	Claimed.... Found......
2706	Blackman Sugar Beet, Onion and Potato	Jackson	Claimed.... Found......
	E. Burton, St. Joseph, Mich.		
2714	Meat and Bone Phosphate	St. Joseph	Claimed.... Found......
	The Buffalo Fertilizer Co., Buffalo, N. Y.		
2913	Bone Meal	Manufacturer's sample	Claimed.... Found......
2761	Celery and Potato Special	Hartford	Claimed.... Found......
2914	Dissolved Phosphate	Manufacturer's sample	Claimed.... Found......
2708	Extra Phosphate and Potash	Coldwater	Claimed.... Found......
2709	Farmer's Choice	Reading	Claimed.... Found......
2915	Garden Truck	Manufacturer's sample	Claimed.... Found......
2710	General Crop	Coldwater	Claimed.... Found......
2711	General Favorite	Coldwater	Claimed.... Found......
2832	Ohio and Michigan Special	Coopersville	Claimed.... Found......

1911, expressed in parts per one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
5.25 5.90	13.17 15.45	....	....	....	$27 86 31 85
1.25 2.99	.... 14.51	.... 6.90	7 7.61	1.25 1.25	12 26 22 36
2.50 2.58	.... 14.16	.... 5.94	10 **8.22**	3 3.00	20 95 21 81
4 **3.62**	.... 15.86	.... 5.22	15 **10.64**	0.36 0.24	28 52 **24 86**
2.90 2.86	22 25.30	....	....	....	27 17 29 06
1.60 2.03	.... 9.75	1 1.02	8 8.73	10 10.05	22 68 24 90
....	.... 17.90	1 1.16	14 16.74	....	14 00 16 74
....	.... 12.92	1 0.82	10 12.10	8 8.15	17 20 19 44
0.80 1.33	.... 10.32	1 1.73	8 8.59	5 5.55	15 54 18 67
3.30 3.29	.... 9.85	1 0.44	8 9.41	7 9.44	25 59 28 95
....	.... 10.65	1 0.86	9 9.79	3 2.93	11 70 12 43
1.20 1.56	.... 10.50	1 1.59	8 8.91	2.50 3.70	14 61 18 03
0.80 1.27	.... 12.32	1 1.85	10 10.17	1 1.83	13 94 17 05

Results of analyses of commercial fertilizers for

Laboratory number.	Trade name.	Locality where sample was taken.	
	The Buffalo Fertilizer Co.—*Con.*		
2712	York State Special	Coldwater	Claimed.... Found......
2939	York State Special	Muskegon	Claimed.... Found......
2839	Nitrate of Soda	Plymouth	Claimed.... Found......
2916	Gleaner Acid Phosphate	Manufacturer's sample	Claimed.... Found......
2713	Gleaner Favorite	Mason	Claimed.... Found......
2852	Gleaner General Grower	Wayne	Claimed.... Found......
2853	Gleaner Phosphate and Potash	Wayne	Claimed.... Found......
2854	Gleaner Special	Wayne	Claimed.... Found......
	Chicago Raw Products Co., Chicago, Ill.		
2948	Consumers Special Acid Phosphate	Manufacturer's sample	Claimed.... Found......
2953	Consumers Special Corn and Oats Fertilizer	Manufacturer's sample	Claimed.... Found......
2949	Consumers Special Corn and Wheat Grower	Manufacturer's sample	Claimed.... Found......
2947	Consumers Special High Grade Wheat Grower	Manufacturer's sample	Claimed.... Found......
2950	Consumers Special Onion and Vegetable Grower	Manufacturer's sample	Claimed.... Found......
	Cincinnati Phosphate Co., Cincinnati, Ohio.		
2859	Black Soil Fertilizer	Willis	Claimed.... Found......

1911, expressed in parts per one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
1.60 1.38	.... 10.82	1 0.85	9 9.97	5 7.08	$19 18 21 23
1.60 1.86	.... 10.60	1 1.12	9 9.48	5 6.04	19 18 21 51
15 15.68	....	....	....	....	49 50 51 74
....	.... 17.90	1 1.32	14 16.58	....	14 00 16 58
1.64 1.97	.... 9.75	1 1.17	8 8.58	4 4.59	17 41 19 68
0.82 1.08	.... 12.20	1 1.80	10 10.40	1 1.39	14 01 15 94
....	.... 11.30	1 1.16	10 10.14	2 2.29	11 80 12 20
0.82 0.91	.... 9.50	1 1.20	8 8.30	4 4.55	14 71 15 88
....	.... 17.40	1 0.83	14 16.57	....	14 00 16 57
....	.... 12.75	1 1.17	10 11.58	2 3.23	11 80 14 49
0.82 1.12	.... 11.35	1 1.81	8 9.54	4 4.93	14 31 18 40
....	.... 11.52	1 0.80	10 10.72	5 6.48	14 50 16 55
....	.... 11.42	1 0.86	10 10.56	10 10.90	19 00 20 37
....	.... 10.55	1 0.74	8 9.81	8 7.44	15 20 16 51

Results of analyses of commercial fertilizers for

Laboratory number.	Trade name.	Locality where sample was taken.	
	Cincinnati Phosphate Co.—*Con.*		
2917	Bone and Phosphate Mixture Wheat Special	Manufacturer's sample	Claimed Found
2918	Dissolved Phosphate and Potash	Manufacturer's sample	Claimed Found
2762	Grain and Grass Grower	Holland	Claimed Found
2763	Tobacco, Potato and Beet Grower	Holland	Claimed Found
2764	Truck and Tobacco Fertilizer	Holland	Claimed Found
2886	Truck and Tobacco Fertilizer	Holland	Claimed Found
2833	Wheat Grower	Coopersville	Claimed Found
	Darling & Company, Chicago Ill.*		
2715	Big Potash Brand	Coldwater	Claimed Found
2887	Big Potash Brand	Ithaca	Claimed Found
2888	Big Potash Brand	Elm	Claimed Found
2716	Chicago Brand	Coldwater	Claimed Found
2717	Farmer's Favorite Brand	Coldwater	Claimed Found
2765	General Crop Brand	Coldwater	Claimed Found
2840	Phosphate and Potash Brand	Elm	Claimed Found

*After the manuscript for this bulletin had been sent to the printers, Darling & Co. licensed a new brand, "Eight Per Cent Phosphate." It is guaranteed to contain 8% available phosphoric acid We found 9.33%.

1911, expressed in parts per one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
1.60 2.02	.... 20.40	6 7.56	10 12.84	1 1.22	$18 58 23 63
....	.... 12.95	1 0.98	10 11.97	4 4.28	13 60 15 82
0.80 0.95	.... 9.32	1 0.49	8 8.83	2 2.05	12 84 14 02
0.80 0.97	.... 9.65	1 0.42	8 9.23	4 3.99	14 64 16 19
1.60 1.66	.... 7.10	1 0.58	6 6.52	6 5.92	17 08 17 56
1.60 1.59	.... 7.90	1 0.70	6 7.20	6 6.16	17 08 18 27
....	.... 13.82	1 1.21	12 12.61	....	12 00 12 61
1.24 1.25	.... 9.63	2 1.00	8 8.63	10 10.24	21 89 22 36
1.24 1.24	.... 11.77	2 1.90	8 9.87	10 10.26	21 89 23 95
1.24 1.17	.... 9.80	2 0.70	8 9.10	10 10.23	21 89 22 14
1.65 1.60	.... 11.47	2 2.79	8 8.68	2 2.11	16 05 16 98
2.47 2.57	.... 13.97	2 3.52	8 10.45	4 4.01	20 56 23 95
0.82 1.05	.... 10.67	2 0.75	8 9.92	6 6.70	16 91 19 72
....	.... 11.41	.... 1.68	10 9.73	2 2.15	11 80 11 67

Results of analyses of commercial fertilizers for

Laboratory number.	Trade name.	Locality where sample was taken.	
	Darling & Company.—*Con.*		
2919	Pure Bone and Potash	Manufacturer's sample	Claimed.... Found......
2920	Pure Ground Bone	Manufacturer's sample	Claimed.... Found......
2766	Sugar Beet and Root Grower Brand	Bay City	Claimed.... Found......
2767	Sure Winner Brand	Hudson	Claimed.... Found......
2921	Ten-Five Brand	Manufacturer's sample	Claimed.... Found......
2768	Vegetable and Lawn Fertilizer	Bay City	Claimed.... Found......
2896	Vegetable and Lawn Fertilizer	Midland	Claimed.... Found......
	Farmers Fertilizer Co., Columbus, Ohio.		
2871	Farmers Acid Phosphate	Belleville	Claimed.... Found......
2872	Bone Meal	Belleville	Claimed.... Found......
2873	Nitrate of Soda	Belleville	Claimed.... Found......
	German Kali Works, Baltimore, Md.		
2769	Kainit	Battle Creek	Claimed.... Found......
2941	Muriate of Potash	Manufacturer's sample	Claimed.... Found......
2834	Sulfate of Potash	Grand Rapids	Claimed.... Found......
	Grand Rapids Glue Co., Grand Rapids, Mich.		
2879	Grand Rapids	Grand Rapids	Claimed.... Found......

1911, expressed in parts per one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
2.14 2.22	20.15 23.30	....	....	6 6.50	$28 59 31 82
2.47 2.54	23 26.15	....	....	....	26 55 29 30
1.65 1.60	.... 10.32	2 1.39	8 8.93	5 5.14	18 75 19 41
0.82 0.78	.... 10.10	2 1.32	8 8.78	3 2.91	14 21 14 50
....	.... 11.25	.... 0.80	10 10.45	5 4.38	14 50 14 39
3.30 3.26	.... 11.97	2 1.45	8 10.52	7 7.48	25 99 28 59
3.30 3.38	.... 12.32	2 2.12	8 10.20	7 7.08	25 99 28 58
....	.... 18.90	0.50 1.14	14 17.76	....	14 00 17 76
1.64 **1.47**	20 **19.65**	....	....	....	21 41 **20 57**
15.50 15.53	....	....	....	....	51 15 51 25
....	....	....	....	12 12.13	10 80 10 92
....	....	....	....	50 50.05	45 00 45 05
....	....	....	....	48 49.33	43 20 44 40
2 2.48	.... 17.80	6 5.68	6 12.12	1 1.09	15 90 23 55

Results of analyses of commercial fertilizers for

Laboratory number.	Trade name.	Locality where sample was taken.	
	Grange Fertilizer Co., Detroit, Mich.		
2770	All Crops Special Fertilizer	Hillsdale	Claimed.... Found......
2922	Complete Manure	Manufacturer's sample..	Claimed.... Found......
2771	Corn, Oats and Grass Fertilizer	Hillsdale	Claimed.... Found......
2923	High Grade Concentrated Wheat Manure	Manufacturer's sample..	Claimed.... Found......
2772	Potato and Vegetable Fertilizer	Reading	Claimed.... Found......
2864	Wheat Fertilizer No. 1	Lennon	Claimed.... Found......
2878	Wheat Fertilizer with Potash	Plymouth	Claimed.... Found......
	Hirsh, Stein & Co., Chicago, Ill.		
2924	Calumet Bone Black Grain Grower	Manufacturer's sample..	Claimed.... Found......
2773	Calumet Bone Phosphate and Potash	Clayton	Claimed.... Found......
2774	Calumet Corn and Wheat Grower	Coloma	Claimed.... Found......
2925	Calumet Fruit and Truck Grower	Manufacturer's sample..	Claimed.... Found......
2835	Calumet Grain Grower	Nunica	Claimed.... Found......
2942	Calumet High Grade Garden and Vegetable Grower	Manufacturer's sample..	Claimed.... Found......
2775	Calumet High Grade Bone Phosphate and Potash	Clayton	Claimed.... Found......

1911, expressed in parts per one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
1.03 1.00	10 11.02	.... 0.89	8 10.13	2 3.16	$14 00 16 65
0.82 1.12	9 10.40	.... 1.44	7 8.96	1 1.33	11 41 14 44
1.65 1.77	10 10.70	.... 0.72	8 9.98	2 2.16	16 05 18 04
1.23 1.42	11 11.60	.... 1.50	9 10.10	2 2.13	15 66 17 31
0.82 0.91	10 11.20	.... 0.89	8 10.31	3 3.26	14 21 16 60
....	16 16.80	.... 2.83	14 13.97	....	14 00 13 97
....	12 12.60	.... 0.68	10 11.92	2 2.08	11 80 13 79
2.05 2.50	.... 11.45	1 0.60	8 10.85	1.50 2.10	16 52 21 23
....	.... 13.46	1 1.48	10 11.98	2 2.35	11 80 14 10
0.82 0.94	.... 10.85	1 2.22	8 8.63	4 4.71	14 71 16 86
4.10 4.30	.... 11.00	1 1.32	8 9.68	7 7.81	28 23 31 33
1.60 1.60	.... 10.00	1 1.40	8 8.60	2 2.19	15 32 16 41
2.05 2.46	.... 10.95	1 0.98	8 9.97	6 7.15	20 57 24 92
....	.... 12.75	1 1.16	10 11.59	5 5.26	14 50 16 32

Results of analyses of commercial fertilizers for

Laboratory number.	Trade name.	Locality where sample was taken.	
	Hirsh, Stein & Co.—*Con.*		
2776	Calumet Potato, Tobacco and Onion Grower........	Zeeland..............	Claimed.... Found......
2880	Calumet Special Grape Fertilizer..................	Lawton..............	Claimed.... Found......
2777	Calumet Special Potato, Tobacco and Onion Grower..	Coloma...............	Claimed.... Found......
2778	Calumet Special Pure Bone Meal...................	Hillsdale.............	Claimed.... Found......
2780	Calumet Special 10% Potash Manure...............	Zeeland.............	Claimed.... Found......
2779	Calumet Sugar Beet and General Crop Grower.......	Coloma...............	Claimed.... Found......
2926	Calumet Ten-Ten Hummer Potash Phosphate.......	Manufacturer's sample..	Claimed... Found.....
2927	Calumet Universal Crop Grower....................	Manufacturer's sample..	Claimed.... Found......
2781	Calumet Wheat, Corn and Oats Special............	Hudson..............	Claimed.... Found......
	Jarecki Chemical Co., Sandusky, Ohio.		
2951	Black Soil Special..............................	Petersburg............	Claimed.... Found......
2895	Black Soil Special..............................	Lulu.................	Claimed.... Found......
2928	C. O. D. Phosphate.............................	Manufacturer's sample..	Claimed.... Found......
2782	Fish, Phosphate and Potash, Tobacco and Potato Food..	Ithaca................	Claimed.... Found......
2783	Lake Erie Guano with Phosphate and Potash.......	Hillsdale.............	Claimed.... Found......

1911, expressed in parts per one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
1.60 2.03	.... 10.52	1 1.62	8 8.90	5 5.70	$18 18 21 38
0.82 1.31	20 23.20	....	....	8 8.06	25 91 30 13
1.60 1.68	.... 10.52	1 1.15	8 9.37	10 10.65	22 68 24 97
0.82 1.30	29.70 32.55	....	....	....	26 47 30 31
0.82 0.98	.... 7.32	0.50 0.99	5 6.33	10 10.45	16 91 19 37
1.23 1.47	.... 10.85	1 1.50	9 9.35	2 2.77	15 26 17 29
....	.... 11.30	1 0.88	10 10.42	10 10.69	19 00 20 04
0.82 1.15	.... 9.35	1 1.30	7 8.05	1 1.53	11 01 13 75
0.82 0.93	.... 10.20	1 1.12	8 9.08	3 3.35	13 81 15 62
....	.... 10.40	1 0.91	8 9.49	8 7.90	15 20 17 51
....	.... 8.90	1 2.56	8 6.34	8 9.81	15 20 15 17
....	.... 13.50	1 1.06	12 12.44	....	12 00 12 44
0.83 0.92	.... 9.30	1 0.53	8 8.77	4 4.28	14 74 15 87
1.25 1.01	.... 10.05	1 0.57	8 9.48	2.50 2.08	14 78 14 91

Results of analyses of commercial fertilizers for

Laboratory number.	Trade name.	Locality where sample was taken.	
	Jarecki Chemical Co.—*Con.*		
2889	Lake Erie Guano with Phosphate and Potash.......	New Boston...........	Claimed.... Found......
2784	Number One Formula..........................	Hillsdale.............	Claimed.... Found......
2785	Special Sugar Beet Grower.......................	Ithaca................	Claimed.... Found......
2786	Square Brand Phosphate and Potash...............	Ithaca................	Claimed.... Found......
2875	Tobacco and Truck Grower.......................	Ithaca................	Claimed.... Found......
	Kalamazoo Rendering and Fertilizer Co., Kalamazoo, Mich.		
2787	Kazoo..	Kalamazoo...........	Claimed.... Found......
	Nitrate Agencies Co., New York, N. Y.		
2929	Acid Phosphate.................................	Manufacturer's sample..	Claimed.... Found......
2930	Muriate of Potash..............................	Manufacturer's sample..	Claimed.... Found......
2931	Sulfate of Potash..............................	Manufacturer's sample..	Claimed.... Found......
2932	Nitrate of Soda................................	Manufacturer's sample..	Claimed.... Found......
	Natural Guano Co., Aurora, Ill.		
2788	Pulverized Sheep Manure........................	Benton Harbor........	Claimed.... Found......
	The Pulverized Manure Co., Chicago, Ill.		
2791	Wizard Brand Manure...........................	Jackson..............	Claimed.... Found......
2943	Wizard Brand Pulverized Sheep Manure............	Manufacturer's sample..	Claimed.... Found......

1911, expressed in parts per one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
1.25 1.25	.... 10.58	1 1.32	8 9.26	2.50 2.50	$14 78 16 17
0.83 1.35	.... 10.32	1 0.79	8 9.53	2 2.17	12 94 16 25
0.83 0.90	.... 9.75	1 0.55	8 9.20	4 4.04	14 74 16 03
....	.... 11.05	1 0.66	10 10.39	2 2.32	11 80 12 48
1.66 1.70	.... 8.60	1 0.68	6 7.92	6 6.01	17 28 19 21
1.50 1.35	.... 8.68	2.50 2.44	6 6.24	3 4.04	14 65 15 32
....	.... 17.50	1 2.22	14 15.28	....	14 00 15 28
....	....	....	....	50 50.50	45 00 45 45
....	....	....	....	48 48.22	43 20 43 40
15 15.13	....	....	....	....	49 50 49 93
2.25 2.34	.... 1.47	0.25 0.20	1.50 1.27	1 2.06	9 93 10 93
1.80 2.16	.... 1.47	.... 0.14	1 1.33	1 1.69	7 84 9 99
1.80 2.27	.... 1.65	.... 0.12	1 1.53	1 2.24	7 84 11 04

Results of analyses of commercial fertilizers for

Laboratory number.	Trade name.	Locality where sample was taken.	
	Pioneer Fertilizer Co., Chicago, Ill.		
2789	Pioneer General Crop Grower	Saginaw	Claimed.... Found......
2877	Pioneer High Grade Acid Phosphate	Harbert	Claimed.... Found......
2876	Pioneer High Grade Phosphate and Potash	Harbert	Claimed.... Found......
2865	Pioneer Potato and Vegetable Grower	Jackson	Claimed.... Found......
2790	Pioneer Truck and Corn Grower	Manufacturer's sample	Claimed.... Found......
2866	Pioneer 1-7-1 Fertilizer	Jackson	Claimed.... Found......
2867	Pioneer 2-8-4 Fertilizer	Jackson	Claimed.... Found......
	Smith Agricultural Chemical Co. Columbus, Ohio.		
2868	Special Potato Formula	Maybee	Claimed.... Found......
2846	Chicago Fertilizer B. B. & P. Brand	Palmyra	Claimed.... Found......
2847	Chicago Fertilizer Calumet Phosphate	Maybee	Claimed.... Found......
2869	Chicago Fertilizer New Leader	Azalia	Claimed.... Found......
2792	Chicago Fertilizer Potash Special	Reading	Claimed.... Found......
2793	Chicago Fertilizer Western Phosphate and Potash	Reading	Claimed.... Found......
2870	Ohio Farmers Ammoniated Phosphate and Potash	Azalia	Claimed.... Found......

1911, expressed in parts per one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
1.65 1.76	.... 12.30	1 3.70	8 8.60	2 2.41	$15 65 18 06
....	.... 17.80	1 0.30	14 17.50	....	14 00 17 50
....	.... 14.02	1 1.55	10 12.47	4 3.56	13 60 15 67
1.65 1.65	.... 10.10	1 1.06	8 9.04	7 7.09	20 15 21 29
0.82 1.07	.... 12.30	1 2.50	8 9.80	4 4.36	14 71 18 25
0.82 0.96	.... 8.50	1 0.84	7 7.66	1 1.44	11 01 12 47
1.65 1.70	.... 11.25	1 1.48	8 9.77	4 3.53	17 45 19 15
0.81 0.78	.... 8.85	.... 0.84	6 8.01	10 10.20	17 68 19 77
1.23 1.27	.... 10.70	.... 1.34	8 9.36	2 2.12	13 86 15 46
....	.... 13.37	.... 1.74	10 11.63	2 2.07	11 80 13 49
0.82 0.80	.... 14.16	.... 3.64	8 10.52	7 6.84	17 41 20 78
0.81 0.91	.... 9.60	.... 0.86	8 8.74	4 4.11	14 27 15 78
0.81 0.90	.... 9.90	.... 0.92	8 8.98	2 2.43	12 48 14 14
0.81 0.87	.... 9.72	.... 0.91	8 8.81	4 4.14	14 28 15 41

Results of analyses of commercial fertilizers for

Laboratory number.	Trade name.	Locality where sample was taken.	
	Smith Agricultural Chemical Co.—*Con.*		
2794	Ohio Farmers Corn, Oats and Wheat Fertilizer......	Quincy..............	Claimed.... Found......
2795	Ohio Farmers Excelsior Phosphate................	Reading.............	Claimed.... Found......
2933	Ohio Farmers Soluble Phosphate and Potash........	Manufacturer's sample..	Claimed.... Found......
2845	Ohio Farmers Wheat Maker and Seeding Down......	Maybee..............	Claimed.... Found......
	Speidel and Swartz, Grand Haven, Mich.		
2836	Celery Hustler..................................	Grand Haven.........	Claimed.... Found......
	Swift and Company, Chicago, Ill.		
2796	Bean and Grain Grower.........................	Galien...............	Claimed.... Found......
2797	Complete Fertilizer............................	Zeeland.............	Claimed.... Found......
2800	Complete Fertilizer............................	Jackson.............	Claimed.... Found......
2934	Diamond S Phosphate..........................	Manufacturer's sample..	Claimed.... Found......
2798	Early Potato and Vegetable Grower...............	So. Haven............	Claimed.... Found......
2890	Early Potato and Vegetable Grower...............	Dearborn.............	Claimed.... Found......
2891	Early Potato and Vegetable Grower...............	Holland.............	Claimed.... Found......
2801	Garden City Phosphate.........................	Jackson.............	Claimed.... Found......
2935	Ground Steamed Bone..........................	Manufacturer's sample..	Claimed.... Found......

1911, expressed in parts per one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
1.23 1.26	.... 9.73	.... 1.42	8 8.31	2 2.25	$13 86 14 50
0.81 0.82	.... 9.82	.... 0.68	8 9.14	7 7.03	16 98 18 18
....	.... 12.45	.... 0.90	10 11.55	2 1.86	11 80 13 22
0.81 0.83	.... 9.75	.... 1.02	8 8.73	2 2.06	12 48 13 32
6 6.51	.... 4.97	0.69 0.69	3.17 4.28	1.25 1.90	24 38 27 75
0.82 0.94	.... 10.17	1 1.24	8 8.93	3 3.41	13 81 15 60
1 1.19	.... 10.25	1 1.28	8 8.97	1 1.26	12 60 14 54
1 1.14	.... 10.90	1 1.72	8 9.18	1 1.59	12 60 15 06
....	.... 12.10	1 0.94	10 11.16	....	10 00 11 16
3.29 **2.64**	.... 10.19	1 1.01	6 9.18	10 **9.04**	26 26 26 43
3.29 **3.35**	.... 9.70	1 2.17	6 7.53	10 **8.37**	26 26 26 99
3.29 **2.44**	.... 9.50	1 1.04	6 8.46	10 10.22	26 26 26 13
....	.... 16.52	1 0.73	14 15.79	....	14 00 15 79
1.65 1.92	20 21.60	....	....	....	21 45 23 62

Results of analyses of commercial fertilizers for

Laboratory number.	Trade name.	Locality where sample was taken.	
	Swift & Company.—*Con.*		
2802	Onion, Potato and Tobacco Fertilizer	Galien	Claimed.... Found......
2936	Potato, Celery and Onion Grower	Manufacturer's sample	Claimed.... Found......
2799	Pure Bone Meal	Jackson	Claimed.... Found......
2801	Special Phosphate and Potash	Zeeland	Claimed.... Found......
2892	Special Phosphate and Potash	Waltz	Claimed.... Found......
2805	Sugar Beet Grower	Alma	Claimed.... Found......
2897	Sugar Beet Grower	Galien	Claimed.... Found......
2944	Sugar Beet Special	Manufacturer's sample	Claimed.... Found......
2806	Superphosphate	Three Oaks	Claimed.... Found......
2807	Truck Grower	Hudson	Claimed.... Found......
2803	Raw Bone Meal	Bay City	Claimed.... Found......
2809	Muriate of Potash	Jackson	Claimed.... Found......
2810	Nitrate of Soda	Jackson	Claimed.... Found......
2808	Vegetable Grower	Bay City	Claimed.... Found......

1911, expressed in parts per one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
1.65	....	1	8	7	$20 15
1.66	10.22	1.16	9.06	7.24	21 52
0.82	....	1	5	10	17 11
1.25	9.65	2.26	7.39	11.83	23 07
2.50	24	....	....	....	27 45
2.63	24.90	....	....	....	28 60
....	....	1	10	2	11 80
....	11.87	0.89	10.98	1.81	12 61
....	....	1	10	2	11 80
....	12.25	1.13	11.12	1.83	12 77
2.50	....	1	8	5	21 15
2.31	12.32	1.72	10.60	6.02	24 34
2.50	....	1	8	5	21 15
2.41	12.85	2.46	10.39	5.13	23 94
0.82	....	1	8	3	13 81
1.23	12.90	2.48	10.42	3.83	18 92
1.65	....	1	8	2	15 65
1.78	10.80	1.54	9.26	2.39	17 91
0.82	....	1	8	4	14 71
0.98	10.82	1.22	9.60	4.00	16 92
3.75	23	....	....	....	30 78
3.97	23.45	....	....	....	31 86
....	....	....	....	50	45 00
....	....	....	....	51.46	46 31
15.63	....	....	....	....	51 58
15.61	....	....	....	....	51 51
3.29	....	1	9	10	29 26
2.95	11.25	0.49	10.76	**9.22**	**29 49**

Results of analyses of commercial fertilizers for

Laboratory number.	Trade name.	Locality where sample was taken.	
	Tuscarora Fertilizer Co., Chicago, Ill.		
2937	Acid Phosphate	Manufacturer's sample	Claimed.... Found......
2811	Ammoniated Phosphate	Zeeland	Claimed.... Found......
2812	Bone and Potash	Coloma	Claimed.... Found......
2813	Michigan Special	Zeeland	Claimed.... Found......
2814	Tuscarora Bone Phosphate	New Buffalo	Claimed.... Found......
2815	Tuscarora Fruit and Potato	Zeeland	Claimed.... Found......
2938	Tuscarora Garden	Manufacturer's sample	Claimed.... Found......
2816	Tuscarora Standard	New Buffalo	Claimed.... Found......
2817	Wolverine Special	New Buffalo	Claimed.... Found......
	Wuichet Fertilizer Co., Dayton, Ohio.		
2818	Buckeye Onion and Truck Fertilizer	Manchester	Claimed.... Found......

1911, expressed in parts per one hundred.—Con.

Nitrogen.	Phosphoric Acid			Potash.	Valuation.
	Total.	Insoluble.	Available.		
....	.... 16.30	0.50 0.32	14 15.98	....	$14 00 15 98
0.82 0.97	.... 9.80	0.50 0.79	7 9.01	1 1.04	10 81 13 47
....	.... 10.65	0.50 0.21	10 10.44	2 2.60	11 80 12 78
1.65 1.70	.... 10.22	0.50 1.14	8 9.08	5 5.94	18 15 20 50
....	.... 11.62	0.50 0.60	10 11.02	....	10 00 11 02
1.65 1.67	.... 10.30	0.50 1.07	8 9.23	10 10.73	22 75 24 83
2.88 2.85	.... 10.50	0.50 1.96	8 8.54	4 4.62	21 30 22 89
1.65 1.61	.... 9.72	0.50 0.84	8 8.88	2 2.07	15 45 16 39
0.82 0.98	.... 9.55	0.50 0.70	8 8.85	4 4.10	14 51 16 06
1.50 1.51	.... 13.23	1 2.31	8 10.92	8 6.84	20 55 22 98

POULTRY HOUSE CONSTRUCTION AND YARDING.

Bulletin No. 266.

BY H. L. KEMPSTER.

The unusual demand for information on poultry raising including house plans has led to the publication of this bulletin. It is impossible to go into detail but a few of the principles of house construction will be given to offer the reader an opportunity to adapt them to his particular needs.

ESSENTIALS OF A POULTRY PLANT.

Convenience of location and arrangement is essential to economy of time in care and management. Many chicken troubles may be traced to the selection of an unsuitable site or soil not adapted to efficient sanitation. Perfect dryness is essential and since this is largely controlled by ventilation, the best possible system should be installed for that purpose. An abundance of light is also essential to healthful conditions and abundant egg production.

LOCATION.

The commercial poultryman should consider the demands, proximity to markets, and shipping facilities before going into further detail. Unsuitable locations are the cause of much trouble in maintaining healthful flocks and generally result in failure. This important feature should be considered from the standpoint of both the commercial poultryman and the farmer. The poultry farm should consist of a light soil such as a sandy loam, but not so sandy but that it will produce an abundance of green food for forage. The lighter, more friable soils can be plowed and cultivated more easily than clays and at any time during the season. They also drain quickly and dry and warm up early in the spring. Heavy clay soils are objectionable for the following reasons, viz: The frequent long continued sticky, muddy condition is disagreeable for the attendant, and dirty eggs result from mud being carried into the nests on the chickens feet. It is more difficult to keep a heavy soil sweet and sanitary as it dries out slowly, thus limiting the possibilities of cultivation and re-seeding which is also restricted when the opposite conditions of extreme dryness and baking occur. Fewer chickens can be kept on the same area of clay as compared with sandy soil. Permanent sod runs are undesirable as they soon become unsanitary. Frequent cultivation and re-seeding with suitable forage crops tends to destroy disease germs by exposure to the air, sunlight and frost, while the droppings are utilized by the crops grown.

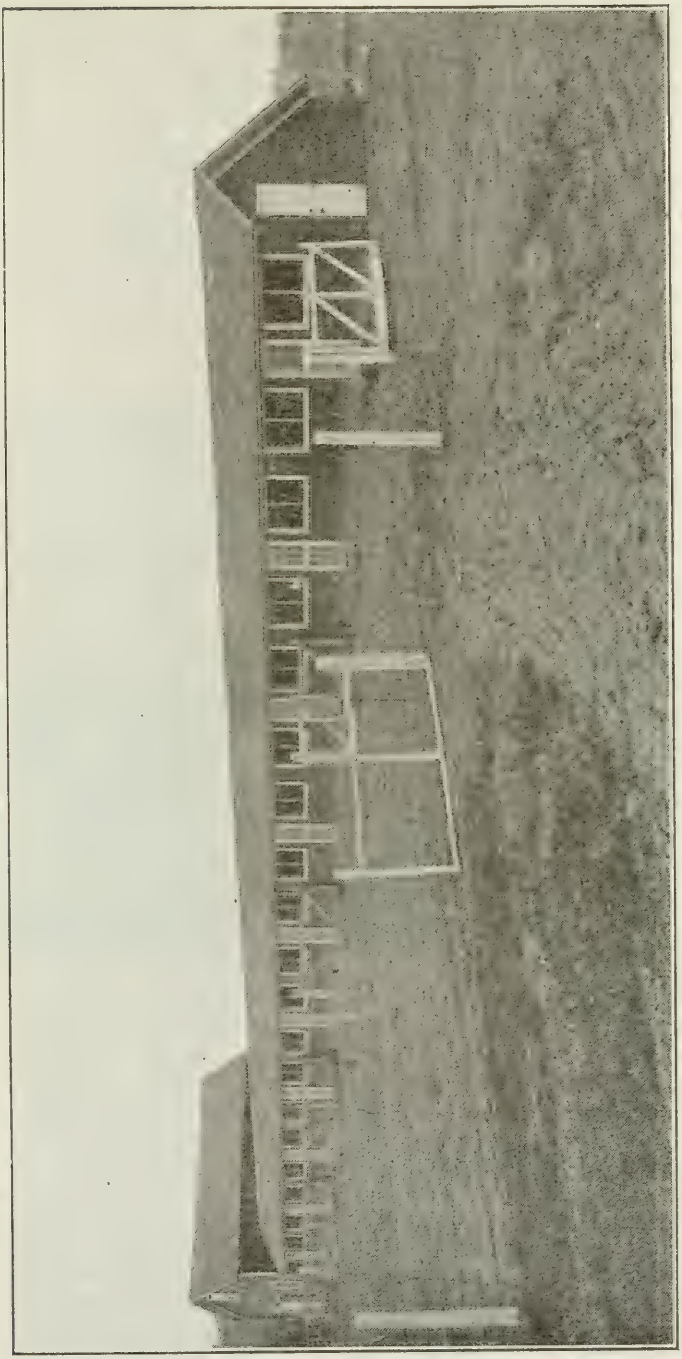


Fig. 1. Commercial laying house.

An ideal location should have a slight slope to the south or southeast, thus enabling it to dry and warm up quickly. If the soil is not naturally well drained a tile drain system should be installed. It is better to locate the houses at the top of an elevation but if they have to be placed on a slope, the ground should be graded so as to divert the water that comes down from above. Good air drainage is essential; poultry houses should not be located in depressions as damp cold air settles in such places. A mistake commonly made on the farm consists in locating the poultry house too close to the other farm buildings which the hens are inclined to overrun and inhabit thus becoming a nuisance. This would not occur if the houses are located some distance from the other farm buildings and the feeding always done there.

In the selection of a site for the poultry plant protection from the prevailing winds should be secured if possible without sacrificing the necessary amount of sunlight.

The possibilities of future development and expansion should be considered and provision made for the extension of the building system as well as supplementary yardage or foraging ground. This is more important to the commercial poultryman, whose operations are more extensive than the farmer. The moving and remodeling of buildings and fences to meet future demands should be avoided as far as possible.

YARDING.

As perfect sanitation is one of the prime requisites to success, the larger the yards are the easier it will be to maintain healthful conditions among the flocks. If the yard areas must be small, more care will have to be exercised. While there is no fixed rule relative to the amount of yard space required, if wholesome conditions are maintained one hundred and forty square feet per chicken will suffice.

Yard fences are not invariably used. There may be exceptional surroundings and special lines of production rendering them unnecessary. Single, double, and triple yard systems are in use at the college. The single yards or those extending out from one side of the house the width of the individual pen are unsatisfactory, being too narrow, thus rendering it difficult to use horses and implements with which to cultivate and reseed. Green forage cannot be started in these yards without confining the chickens or vacating the house.

Double yards, with one located on each side of the pen, are more satisfactory. They can be used alternately during the season with chickens foraging on one yard while a fresh crop is being started in the other, thus using the pen continuously, or the yard may be used alternate years. Occasion may permit the combination of two adjacent pens thus allowing yards of double width as in the case of the commercial house at the college with individual pens 18 feet in width and the adjoining yards 36 feet. This arrangement reduces the cost of fencing considerably and greatly facilitates the working of the soil, and in addition affords the chickens a greater amount of ranging area. By this plan all cross-fences can be eliminated should special conditions permit. For long continuous houses double yards are most satisfactory.

Frequent cultivation of the yards and constant renewal of forage crops are the main essentials in maintaining sanitary conditions.

A three-yard system has been used in connection with single colony houses with one yard located on each side as well as one at the end. Only two yards are used at once while a crop is being started on the third. One yard is sown to wheat or rye in the fall and another to oats as early as possible in the spring while the chickens occupy the third, but are let in to forage on the wheat shortly before feeding time each night to prevent waste by trampling. When the oats are nicely started the poultry is given access to it and the wheat as well, while the third lot is being seeded to oats. Buckwheat is used later on for green food.

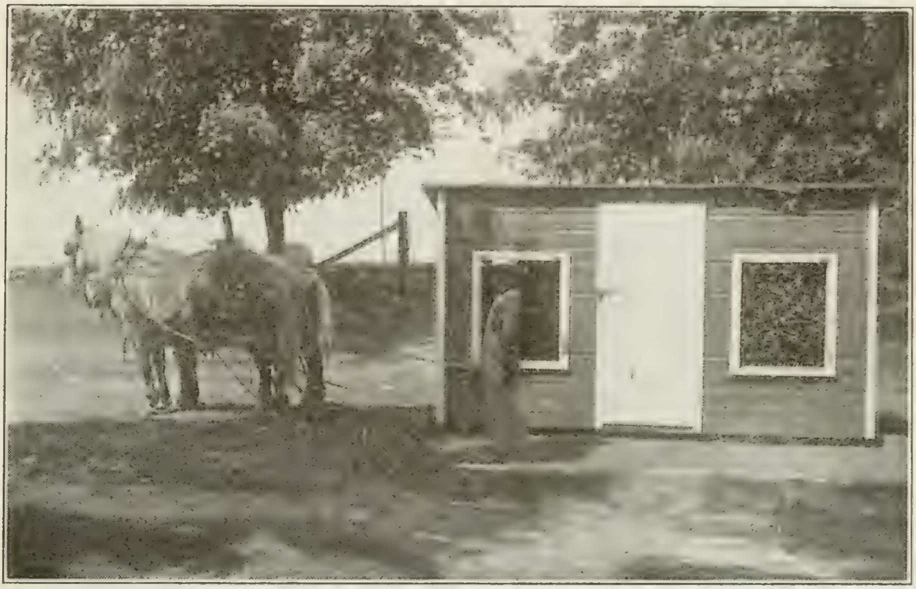


Fig. 2. A portable house on runners greatly relieves the necessity for yarding young chicks.

The portable house on runners, which can be moved from one place to another, greatly relieves the necessity for yarding young chicks. Such places as the farm lane, orchard or cornfield may be utilized furnishing fresh soil, sunlight and shade, and an abundance of insect and other food conducive to healthy conditions and rapid growth.

Yard gates should be made large enough to permit the passage of all equipment, even such as portable houses. This matter is frequently overlooked resulting in additional labor and expense.

From the farmers standpoint yardage is desirable at times. In the early spring, during the cold, wet, muddy weather the chickens ought to be enclosed and they should not be permitted to run with the young during the brooding period as the latter will not thrive as well if compelled to pick their living with mature fowls. As a rule the farm

poultry yards remain unchanged and uncultivated year after year providing an opportunity for the development and perpetuation of disease.

FORAGE CROPS.

Both the farmer and commercial poultryman should plan to grow green crops for forage though the need of special crops is not so great in the former case. This is a cheap method of furnishing a great abundance of succulent food as the chickens help themselves thus eliminating

Fig. 3. Young chicks will not thrive as well if compelled to pick their living with mature fowls.

the expense of harvesting, etc. Wheat or rye can be sown in the fall, oats or barley in the early spring followed by oats and rape, succeeded later by rape and buckwheat. While permanent sod runs of grass are not desirable, alfalfa is an exception being satisfactory because of its rapidity of growth and the high quality of food it furnishes.

SHADE.

Protection from the summer sun in and about the yards is very essential to the health and comfort of the flocks. Many different kinds of shade trees may be used but fruit trees can be made to provide protec-

tion and produce revenue. Plum trees grow more rapidly than apples or pears, and all furnish suitable shade but should not be planted so thickly as to produce dampness. For temporary shade sunflowers and corn are unexcelled.

HOUSING.

Money is often spent unnecessarily in providing expensive building equipment. Unduly artificial conditions are neither essential nor desirable in successful poultry growing. A plain, simply constructed house

Fig. 4. For temporary shade corn is unexcelled.

well lighted, dry, and properly ventilated without draft, is all that is required. The interior fittings should be simply designed with as few cracks and dark corners as possible thus aiding in the suppression of lice and mites and avoidance of disease due to the lack of light and dryness.

FOUNDATION.

A stationary poultry house should be constructed on a good foundation. Posts, set in the ground, are objectionable as they decay rapidly, while blocks and stones are so easily moved by frosts, etc., that they are not satisfactory. Special precautions are necessary with these foundations to exclude vermin. It is difficult to repair a house warped from the use of unstable foundations as all joints, doors, windows, etc.,

are affected. While a wall may be constructed after the building has been completed and in use, still, this is unsatisfactory and an additional expense. Concrete walls probably are the most satisfactory being easy to construct. They should be placed below the frost line extending at least eight inches above the ground line and need not be as heavy as for the other farm buildings. The super-structure can always be more easily and satisfactorily built when the top of the wall is level rather than following the ground slope as is sometimes done. Bolts should be placed in the top of the wall to fasten the sills down; this is very essential with buildings of such light construction which are likely

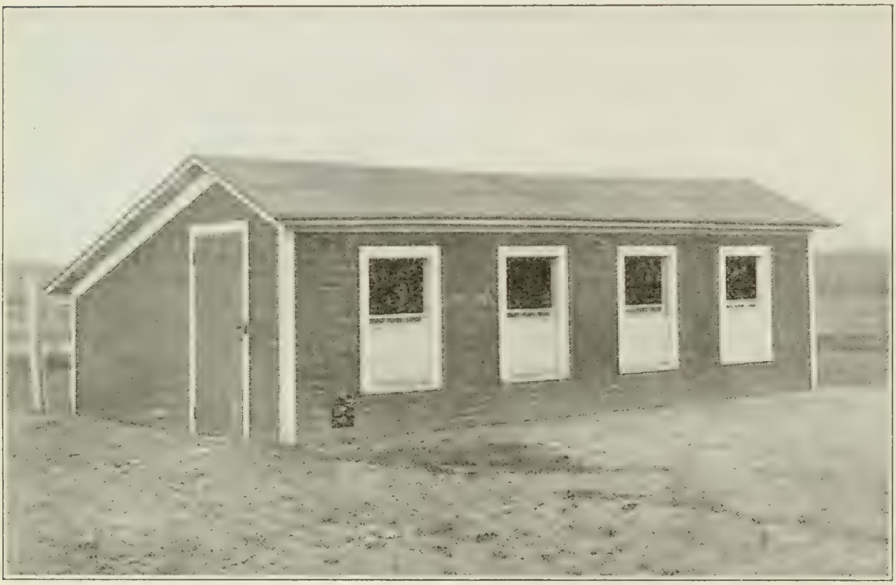


Fig. 5. A plain simply constructed house is all that is required. Farmers colony house.

to be seriously affected by severe windstorms. If the foundation is filled up to or near the top of the wall, and the ground properly graded outside so there is a slope away from the house in every direction, there will be no danger of surface water affecting the condition of the floor.

FLOORS.

The floor should be of moderate cost, and absolutely vermin proof. Three types of floors are used, viz.: earth, wood and concrete. The earth floor is the cheapest and generally as serviceable as any. It should be raised in line with the top of the foundation to prevent dampness as the water level is the same within the house as out. The fine earth removed as the houses are cleaned should be replaced occasionally to maintain the original floor level.

In using earth floors, if the soil is not well drained, precautions must

be taken against moisture which rises like oil in a lamp wick. This can be prevented by separating the earth fill from the soil beneath by a three or four inch layer of stones or cinders. It is claimed that cinders tend to check invasions of rats usually troublesome with earth floors. It is said that earth floors are harder to keep clean and that the litter becomes dirty more quickly than with board or cement floors; economy in construction and the ever present dust bath are however commendable features. The foul earth to the depth of a few inches should be replaced at least once each year in maintaining good sanitation.

Board floors are rarely used except in portable houses because of their expensiveness and the suitable conditions they furnish for harboring vermin.

Concrete floors, favored next to earth, are increasing rapidly in use and popularity. While the first cost of the concrete floor is greater, it is durable, dry, clean, and can be perfectly disinfected in case of disease. This type of floor is objected to as being cold but the objection can be overcome by the use of a deep straw covering. An earth floor may be tried first and if unsatisfactory, replace by concrete later.

WIDTH OF POULTRY HOUSE.

The width of the house depends entirely upon its use. Breeding houses are usually narrow because a limited number of birds are kept in one pen. Laying houses are generally 14 feet to 20 feet wide. The wider the house the more economically it can be built per square foot of floor space.

HEIGHT OF HOUSE.

The height of house depends upon its kind; sufficient room for working comfortably is all that is necessary. Generally speaking, continuous houses have their high side to the south, especially those which admit all light from that direction, in which case not less than six feet is needed in front with at least four feet in the back. In order to permit the light to extend to the back of the house, a 16 foot width should have a 7 foot front, 18 foot width, 7½ foot front, etc. The height of front would also depend upon the style of roof used but from the standpoint of lighting from the south side these rules should be observed in order to properly light the building.

STYLE OF ROOF.

The most suitable style of roof depends entirely upon the type of house. The commonest form used is the shed roof, sloping one way, best adapted to the narrow house facing the south. A roof of this kind with the high side to the south sends all the water to the rear, is simple to construct and will not absorb as much heat as the combination or gable roof, upon a portion of which the sun's rays strike more directly. The shed roof should not be used on houses over fourteen feet wide as the length of span will permit sagging and in order to secure a

sufficient pitch to the roof the front would need to be excessively high thus causing greater cost of construction.

Another type of roof frequently used is the gable form which does away with the long span, thus being adapted for use on wider buildings. In addition it affords a greater pitch which is desirable in the use of shingles. The objections to its use are that it is necessary to have the back side of the house as high as the front, thus causing a waste of material upon the back, ends and partitions.

The combination roof is in reality a roof combining the features of the shed and gable roof having unequal spans, the shorter usually being about one-third the length of the longer. This roof has the advantage of both types in that it can be used on a house wider than the

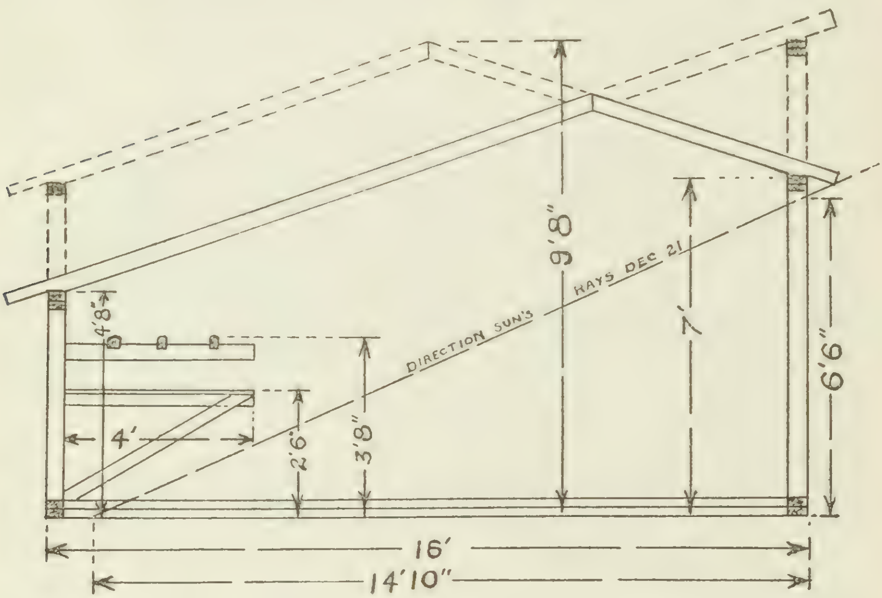


Fig. 6. Types of roofs.

shed roof type, affording a steeper pitch with less cost for siding. In addition the back side of the building is no higher than with the shed roof thus making it much more economical to construct than the gable roof. It should be remembered that as long as the pitch of the roof remains unchanged the material used for all three styles of roofs is exactly the same and the saving in material occurs in the sides, ends and partitions. Bearing this in mind an examination of figure six will show the desirable features of this type of roof as compared to the shed or gable when used on a house sixteen feet wide and having one foot rise to every three feet horizontal run. The dotted line shows the average angle of the sun's rays for Dec. 21, which indicates the necessity of placing the windows 6 feet 6 inches high in order for the sunlight to reach the far side of the house within. The front of the house

is 7 feet high to permit this arrangement of windows, while the back of the house is only high enough to work in conveniently. The shed roof would be 9 feet 8 inches high to the top of the plate or 2 feet 8 inches higher than the combination roof. The gable roof in the back would be 7 feet high, while 4 feet 8 inches is as high as necessary, causing a waste of material in the back of the house. It is apparent that for these specific conditions the combination roof has the advantage over the other two types commonly used in poultry houses.

VENTILATION.

The most important essential in a poultry house is an efficient system of ventilation, affording an abundance of fresh air without drafts. Fresh air insures dryness in the poultry house. A damp cold atmosphere is much more disastrous than a dry extremely low temperature.

Ventilation may be secured by patent ventilators, straw lofts, muslin curtains, and open fronts. Patent ventilators are seldom used on account of the cost of construction and the unsatisfactory manner in which they operate in the low types of building.

The straw loft is made by leaving spaces of one-inch or more between the ceiling boards which are covered with a foot or so of loose straw. Both ends of the loft should have openings, the one on the windward side being kept closed during cold weather while the other should remain open. This method of ventilation has a double advantage in that it not only affords an abundance of fresh air, but the straw takes up the moisture readily, thus rendering the house dry and producing a satisfactory system of ventilation. In addition the house with a straw loft is very desirable during hot weather the temperature being influenced less by the heat from the sun.

Muslin is being used, in part, in place of glass windows to secure fresh air and is exceedingly popular because of its economical features. Houses with one square foot of muslin and one square foot of glass to every eighteen square feet of floor space are common, the amount varying from one foot of muslin to twenty feet of floor space in a house ten feet wide to one foot of muslin to ten square feet of floor space, in a house twenty feet wide. Some poultrymen are building houses with all the windows covered with muslin and where this is done double the amount of muslin previously mentioned should be used. A combination of glass and muslin is preferred and is satisfactory if properly used. The house should be aired out each day more than the muslin permits, for as soon as the cloth becomes damp it will not allow the air to pass back and forth thus rendering the ventilation imperfect. Should the walls and ceiling become damp insufficient ventilation is being used or the house is not sufficiently aired out during the day. Any odors in the house indicate deficient ventilation and more fresh air should be admitted. Fresh air is essential to insure a healthy flock, but in supplying it one must not overlook the danger of drafts. Drafts can be avoided by placing all openings on the south side of the house and also by placing the muslin frames at such a height that when open the air will circulate over the birds on the floor. Frames can be hinged

at the top or side or made to slide up and down as part of the window, in any convenient manner to suit the individual requirements. A moderate sized frame also permits more efficient control of ventilation as one often finds that with large curtains the air is too close, if kept closed, but if kept open the quarters are uncomfortable. In building any poultry house its summer use should also be considered and provision be made for openings in the back so as to afford a free air circulation.

The Fresh Air House has recently come into prominence. It is built with the low side, which is not over four feet high, to the south, and the high side to the north, the south side being covered with a wire screen. The open front works most advantageously on a house 16x20 feet wide although it can be used on a narrower house, providing the amount of open space is reduced. About 1 square foot of open front is used to every 6 to 10 square feet of floor space.

As the south side is low it is necessary to insert extra windows which are usually placed in the west end. These can be removed during the summer thus affording free movement of air and counteracting some of the objectionable feature of the extra amount of heat resulting from having the long slope of the roof to the south instead of to the north as is usually the case. The house is self-regulating so far as ventilation is concerned adapting itself to temperature changes without necessitating the constant attention of an attendant. The roosts being located on the back side are out of the drafts and the snow and storms do not drive in to any great extent. For breeding stock it is exceedingly popular and in some localities it is strongly advocated for egg production. From the standpoint of healthy flocks this type of house is not to be excelled and as a colony house it is being used to a considerable extent. Up to the present time it has not been used extensively as a continuous house because of the necessity of extra light other than that from the south side, but should the type of roof be slightly modified and a break in the roof made, in which windows can be placed straight up and down as in the semi-monitor house, there is no reason why the open front plan cannot be used with a continuous house.

WINDOWS.

Extremes in temperature, in a poultry house, should be avoided as far as possible. This was the objection to the old glass front house which warmed up in day time but radiated a corresponding amount of heat at night. The effect is the same as bringing a chicken in out of the cold, letting its comb become tender due to the warm room, and then taking it back into the cold again. Frozen combs are quite often due to rapid extremes in temperature rather than continued cold; for this reason the old glass front house has given way to the muslin-glass combination and to the open front. When used in combination with muslin or open front, one square foot of glass should be used to every 16x20 square feet of floor space.

For the most efficient lighting it is more desirable to place the windows high than low. In a house 14 feet wide the tops of the windows should be placed 6 feet high; 16 feet wide, 7 feet high; 18 and 20 feet

wide 7 feet 6 inches high. A convenient sized light to use is 8x10 inch or 9x12 inch as a smaller pane interferes with the light, while larger are more expensive to repair when broken.

WALLS.

It is essential that the walls be free from cracks so as to avoid drafts. Rough boards with the cracks battened can be used to advantage although rather expensive so far as the amount of material is concerned, and in addition the battens are apt to become loose and uncover the cracks. Rough boards covered with roofing paper make an excellent house although one must consider the labor and expense necessary to keep it in repair. Ordinary cope-siding is often used, making a suitable and attractive wall, but it is rather expensive. A serviceable wall may be secured by the use of flooring which can be boarded up and down and matched with tighter joints than the cope-siding. The joints should be painted while being laid. Cement walls have not been popular in poultry houses.

CONSTRUCTION.

It is not considered necessary to construct a house with double walls. The dead air space works like a refrigerator causing the birds to suffer more discomfort than in a tight single wall house. Occasionally this air space is filled with straw, sawdust, or some similar material, thus affording an excellent harbor for rats and mice. Frequently, air passages are made between the stuffed space and the room, which does away with the refrigerating effect but provides a suitable place for lice and mites to accumulate. There is no need of lining or lathing and plastering a poultry house, for aside from the appearance and the elimination of a few cracks in the interior it is a useless expense. Ceiling the house above is also considered unnecessary especially for winter use. but for summer use the house with dead air spaces between walls and above is much cooler.

TYPES OF PENS.

Another problem often encountered is the type of pen to use. For years people saw the need of exercise for the laying and breeding hen, and to stimulate this and get the hen out into fresh air, scratching sheds were built. This was a step from the old closed house toward the modern fresh air type. Accordingly screened fronts were made which permitted the bird to get out into fresh air during the day but they were compelled to go back into the closed quarters at night. Many poultrymen are using this plan today, having the roosts in a closed compartment, not realizing that fresh air is as important at night as in the day time. This type of pen has gradually given way to the simpler method of having the roosts and scratching shed in one general room, this plan being less expensive to build and affording a greater amount

of floor space for scratching purposes, while the roosting quarters are aired out in the day time.

CURTAINED ROOSTING CHAMBER.

Formerly a curtain was dropped down in front of the roost to afford a warm roosting chamber, corresponding to the closed roosting quarters in the old type of house. This has gradually fallen into disuse and the builder is advised to try the open roost plan first before going to the expense of a drop curtain.

SIZE OF PEN.

The size of pen depends entirely upon the purpose for which it is to be used. The smaller the flock the greater the production that can be expected from each individual and the greater the labor and expense incurred. For special mating, pens to accommodate 8 to 20 birds fulfill the requirements, while for laying purposes pens to accommodate 50 are more economical, although as many as 500 to 1,000 are sometimes kept in one pen, a system not to be practiced by the poultry man until he thoroughly understands the business.

FLOOR SPACE PER BIRD.

While no definite rule can be made relative to floor space per bird because it depends upon the attention and care exercised, yet in general 4 to 5 square feet of floor space is considered a safe estimate of the amount required under ordinary conditions.

ROOSTS.

The most desirable roosts are those which combine convenience, simplicity and economy. Satisfactory roosts can be made from 2-inch by 2-inch strips for short spans, and 2-inch by 4-inch for longer when the upper corners are rounded and the upper surface is grooved to admit oil. Various other materials such as poles can be utilized for this purpose to a good advantage. Roosts should be about one foot apart and one foot from the wall, placed upon a level or nearly so, to prevent crowding on the one higher up and allowing at least eight inches of roosting space per bird. By fastening together and hinging or hooking to the wall, the roosts can be very conveniently handled or they can be laid in sockets or brackets, care being taken to have them firm. Roosts placed as far as possible from the openings in the house tend to prevent drafts reaching the birds. The height from the floor depends upon the breed, varying from two feet high for the heavy breeds to four or even five feet high for the active breeds.

DROPPINGS PLATFORM.

In order to facilitate cleanliness in the house and to greatly reduce the amount of filth, droppings boards should by all means be used. By using a little precaution in placing the droppings boards so as not to obstruct the light the entire floor space beneath can be utilized for a scratching floor. At least six inches should be allowed between the droppings boards and the roosts, the distance depending entirely upon the arrangement of the roosts. If the platform is made in sections it can be handled much more easily, as it is frequently found desirable to remove them in cleaning. Smooth flooring is the most desirable material to use; when expense is not considered the cleaning is greatly facilitated if this is covered with tin or sheet iron.

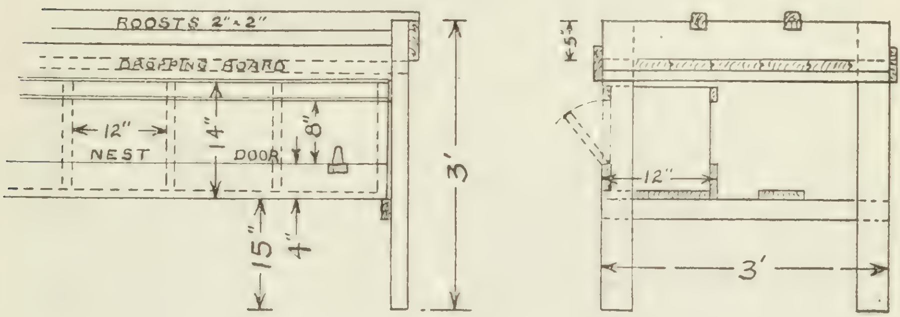


Fig. 7. Nests located under droppings-boards.

PARTITIONS.

Although drafts are prevented to a considerable extent by having all the openings on one side of the house, yet in long houses drafts can be created by the wind driving in one window and out another. In order to avoid this solid partitions of boards or a combination of wire screen and canvass can be installed at intervals of about 50 feet. Occasionally these solid partitions extend out only the width of the roosting chamber, but all partitions should be solid for two to three feet from the floor to break drafts and prevent fighting through the wire netting.

NESTS.

Convenience in handling and usefulness are the main requirements for satisfactory nests. Portable nests greatly facilitate cleaning while darkened nests not only afford a feeling of security on the part of the hen but also tend to reduce the amount of egg eating.

Fig. 7 shows a method of locating nests under the droppings boards still maintaining these requirements. After the droppings boards have been made, the nests are constructed and placed underneath, merely

resting upon cleats at each end, so that they can be removed and cleaned without interfering with the rest of the structure. The nest portion is made with a board one foot wide as a base on the front and back of which is nailed four-inch strips. The partitions at intervals of one foot, are 1 by 12 by 13 inch pieces, while along the top on each side of these are nailed, two-inch strips. Between the strips on the front a door is hinged at the bottom, thus permitting the sections of nests to be opened for the removal of eggs. Back of the nests, on the cleats, is placed a four-inch board for the birds to walk along until they reach their particular nest. The section can be built any desired length and placed any convenient distance from the floor. If the nests are placed high enough to permit the free use of the scratching floor, the roosts are

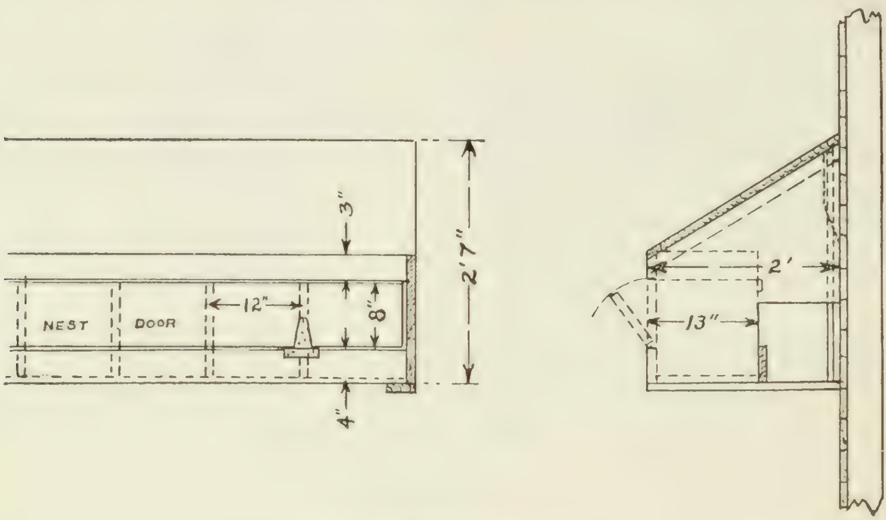


Fig. 8. Nests hung on wall.

apt to be too high, but this interferes only with certain breeds and is offset by its economical and efficient features.

In order to prevent the nests from interfering with the arrangement of the droppings boards Figure 8 shows a type adapted to this purpose possessing the desirable features of the nest heretofore described but requiring more time and material for its construction. Being hung on the wall it can be placed at any desired distance from the floor depending entirely upon the breed kept. For the base, a one-foot board of the desired length is used, having four-inch stripes nailed along the edges. Running across the base at each end on the under side is nailed a 3-inch strip 2 feet long and at the outer end of these are erected two strips, one 2 feet 4 inches long, the other 2 feet 6 inches long, which have been previously nailed together, the shorter one being on the outside. The upper ends of these double strips are then connected by a 1x3-inch strip, set in the space left by having the outer strip the shorter of the two. One foot from each end of the base is inserted a board 1 by 12 by 14 inches and along the upper outer edge of this is

nailed a 1 by 3 inch strip the length of the base board, the ends of the strip then being connected to the upper ends of the double strip previously mentioned by a 1x3-inch strip. After inserting the remaining partitions, the top and ends can be boarded up leaving an opening at each end for the birds to enter and walk along. A door can be placed in the front as in the other nest. For convenience this nest, when once constructed, is hard to excel. Due to the sloping top, birds are unable to roost on it and the ends can be closed readily at night to prevent a persistent setting hen from spending the night on the nests. Other nests such as open boxes, nests built in permanently and covered with a sloping top which permit the bird to enter from the front instead of back are quite commonly used, while many types of trap nests which mean an endless amount of labor are frequently found. The secluded features of the nests described are very desirable, and the sloping top on the latter prevents chickens from roosting on it, thus making it one which can be kept clean with comparative ease.

ALLEY.

For exhibition houses where visitors are frequent and the flock is continually being inspected it is most satisfactory to have an alley, as the constant excitement of having visitors in the flocks is not conducive to good results in laying or breeding pens. From the standpoint of the poultry farmer, where space and equipment is limited, the alley is an expensive luxury for it occupies about one-quarter of the space that might be used for housing chickens besides being an expense to keep clean and unless there is a door from one pen to the next direct, it incurs more labor in caring for the flock.

DUST BATH.

Provisions should be made for a dust bath in every pen, for the problem of dealing with lice is greatly reduced by its presence. The objection that it creates dust in the house is greatly overcome by its beneficial features and a closed bath with a special window in the south side and accessible by a small opening can be easily constructed which has an additional advantage in that it is comparatively free from the danger of any dirt or litter accumulating from the pen. Fine road dust, finely sifted coal ashes, etc., are very desirable materials for the dust bath, and the addition of lime, tobacco dust and patent preparations tend to make it more effective.

WATER STANDS.

In order to keep the drinking utensils clean and sanitary it is desirable to use water stands about 18 inches high to prevent straw and dirt from collecting in and about the pail.

FARMERS COLONY HOUSE.

The average farmers flock varies in size but in the designing and construction of a farmers colony house seventy laying hens will be taken as a basis. Figures 9, 10, and 11 are drawings of houses adapted to this number and one which has been in satisfactory use at the college for some time. Also see figure 5.

The house 14x24 feet in dimensions is built on a wall 6x8 inches above the ground which is filled in to the top making the floor dry at all times of the year. The south or front side is 6 feet 8 inches high, the back 4 feet 8 inches, while the plate and sills are made of 2x4-inch material thus making the studding 6 feet long in front and 4 feet in the

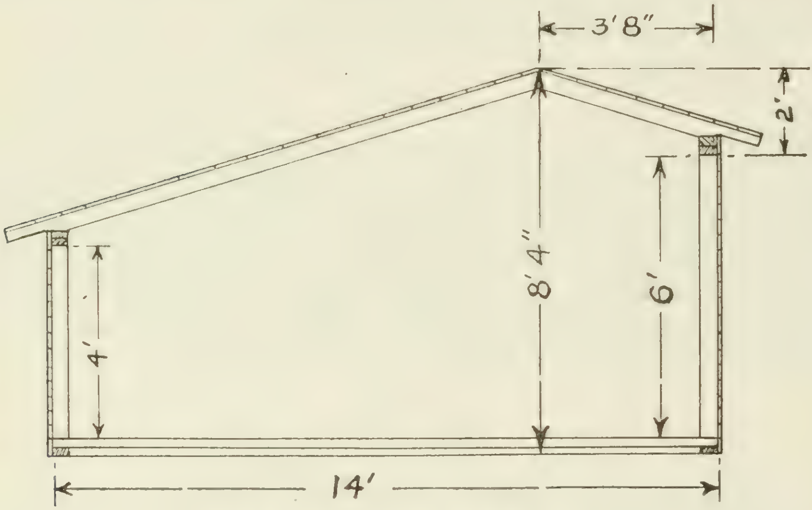


Fig. 9. Farmers' colony house, end view.

back, these being placed 2 feet apart. The combination type roof being comparatively flat having one foot rise to every three feet horizontal run, is covered with a special prepared roofing. With this house, a shed or single span roof could have been used to an equal advantage. The front shows the style of ventilation, which is of the muslin front type. It consists of four windows, each having for its upper sash a muslin frame 2 feet 4 inches by 1 foot 11 inches which slides up and down, while the lower sash is a six light 8x10-inch glass window. There is approximately 16 square feet of muslin to 336 square feet of floor space or 1 square foot of muslin to every 21 square feet of floor space, and also an equal amount of glass. The muslin frames are of a convenient size for the control of ventilation, it being possible to open as many as necessary to supply the required fresh air, varying the number with the nature of the weather, and by placing the muslin frame as the upper sash there is no draft on the birds on the floor. During the

coldest weather one of the frames and often more is kept open all day in order to keep the birds in a healthy condition. The windows are not placed as high as desirable for the most efficient lighting of the house. The roosts located on the back side 3 feet 8 inches from the floor are made of 2x4-inch material placed on edge the upper corners being rounded off. They are merely set in notched boards at each end and can be easily removed for cleaning purposes. About 1 foot beneath are the droppings boards. Located on the back wall is a section of nests previously described and on the end is a feed box 4 feet by 14 inches with a 16-inch front and 24-inch back which is divided into two parts for the holding of whole and ground grain. This is a simple, convenient house, and has given excellent satisfaction.

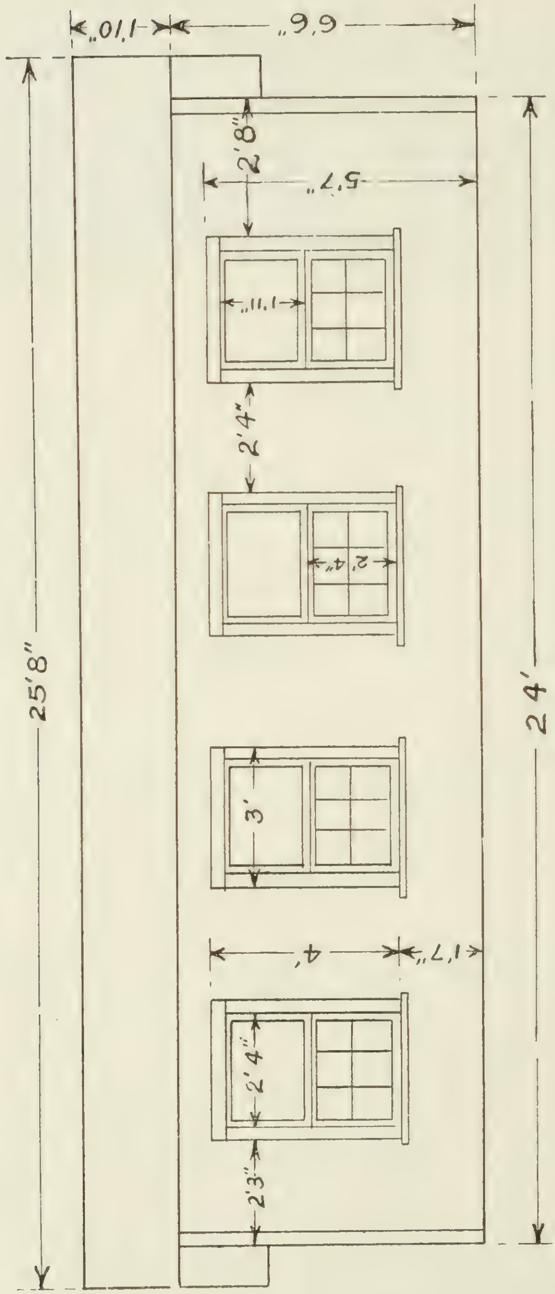


Fig. 10. Farmer's colony house, front view.

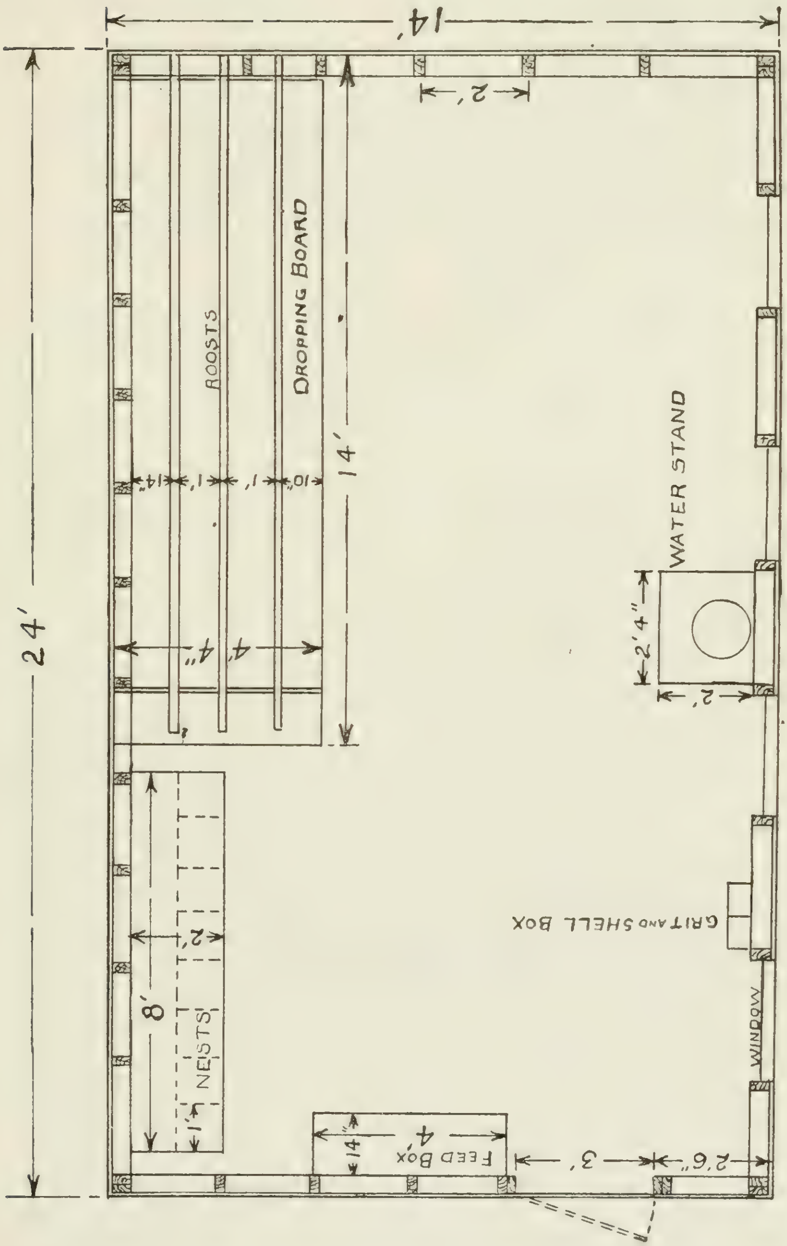


Fig. 11. Farmer's colony house, floor plan.

COMMERCIAL LAYING HOUSE.

Figures 12, 13 and 14 (see Fig. 1) are drawings of a single section of the long laying house at the college, each section being 18 feet square thus accommodating 65 birds. The sills are made of two 2x6-inch pieces and the plates of two 2x4-inch. The front is 7 feet 8 inches high and the back 4 feet 8 inches, the studs are 7 feet and 4 feet long respectively. The roof is of combination type and being comparatively steep having 1 foot rise to every two feet horizontal run. Shingles are used instead of prepared roofing, being better adapted to the steeper roof. No alleyway is used in this house and the pens are connected by a series of doors thus utilizing all the space and compelling the attendant to mingle with the birds where he is able to study their needs and conditions much more thoroughly.

The open front method of muslin ventilation is used in this house with a different arrangement of windows than in the house previously described. In the center of the south side is a glass door made by hinging two 9 light 9x12-inch glass windows, thus affording 15 square feet of glass to 324 square feet of floor space and also a door that can be opened for cleaning purposes. On both sides are muslin frames 3x5 feet which being 4 feet from the floor do not permit drafts on the birds when open, one being opened every day during the winter, although closed at night. Had these frames been made into two sections it would permit a more perfect control of the amount of fresh air in the house, but it is very satisfactory as it is.

The house is ceiled on all sides and above which would not be advisable in a commercial house. The arrangement of the droppings boards, roosts, etc., are as in the farmer's colony house, except that they are placed about one foot lower to accommodate the heavier breeds. The roosts are also set on 2x4-inch pieces in the form of a frame which is hinged at the back and can be raised, thus rendering the droppings boards easily accessible for frequent cleaning; it is desirable to raise the roosts so as to force lazy hens to the floor. The floor is made of cement and any tendency toward cold is eliminated by the liberal use of straw which in addition compels the hen to exercise in her search for food. For ease in cleaning all fixtures are portable and all nests and boxes have sloping tops, thus eliminating the accumulation of filth on the internal fixtures. This house is well adapted for commercial use as its use at the college has demonstrated.

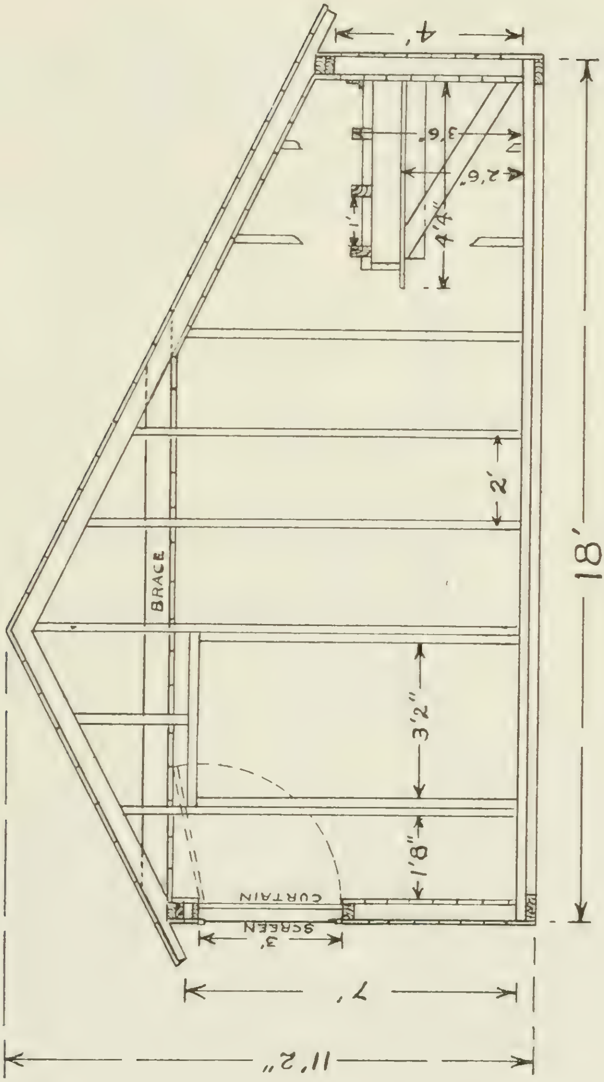


Fig. 12. Commercial house, end view.

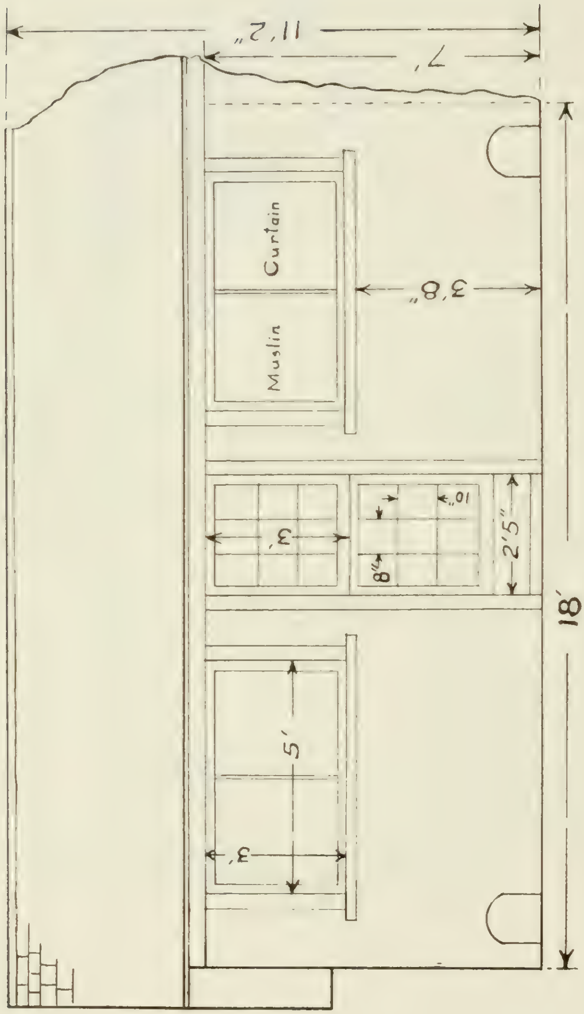
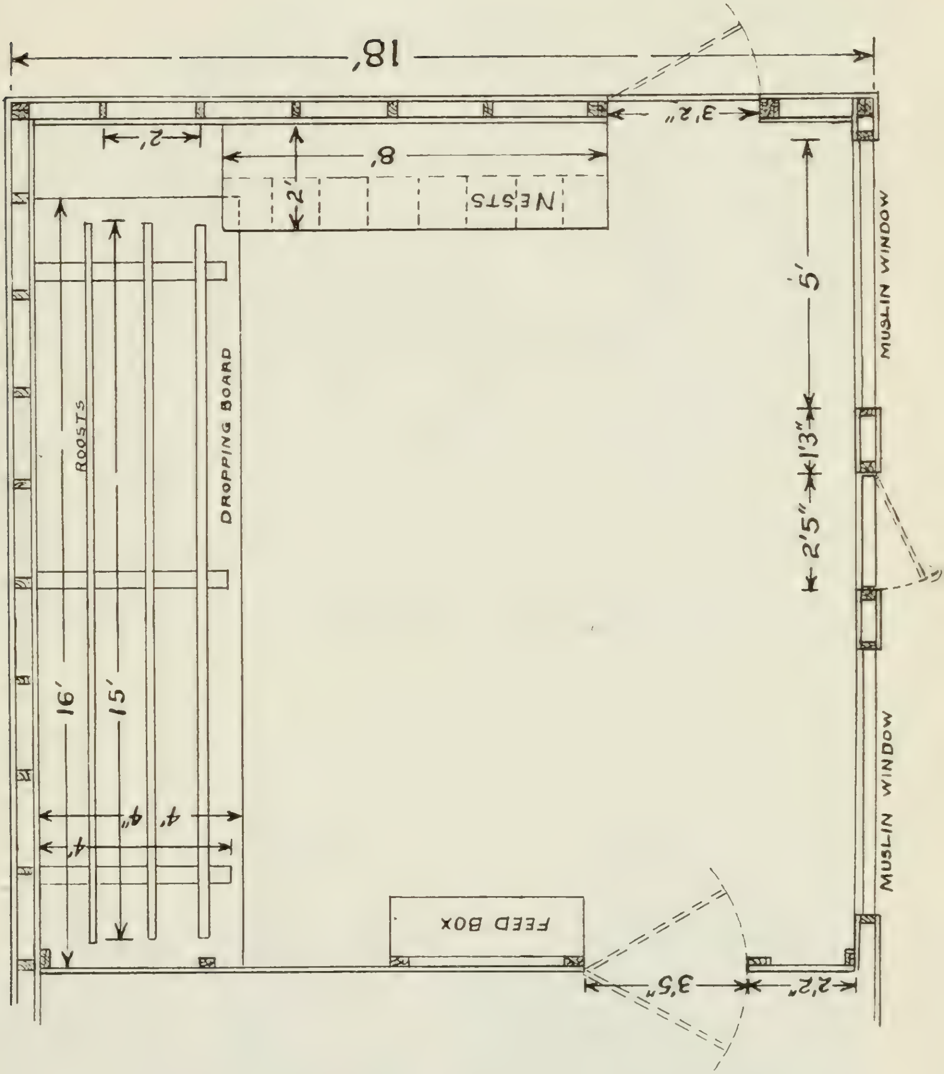


Fig. 13. Commercial house, front view.


18'
3'2"
2'
8'
2'
NESTS
5'
MUSLIN WINDOW
1'3"
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ROOSTS
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16'
15'
4' 4"
4'
FEED BOX
3'5"
2'2"
MUSLIN WINDOW

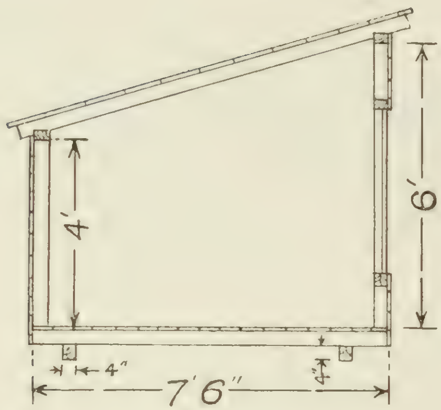


Fig. 15. Portable colony house.

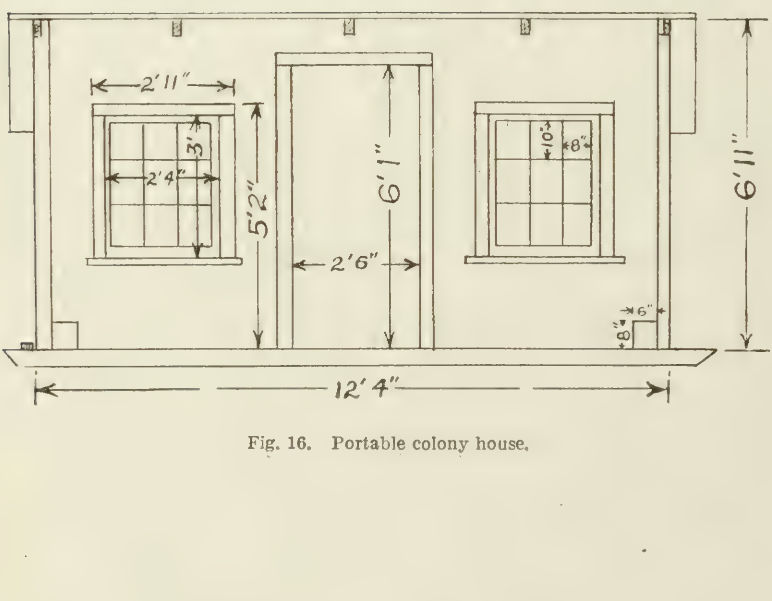


Fig. 16. Portable colony house.

Fig. 17. Portable colony house in process of construction.

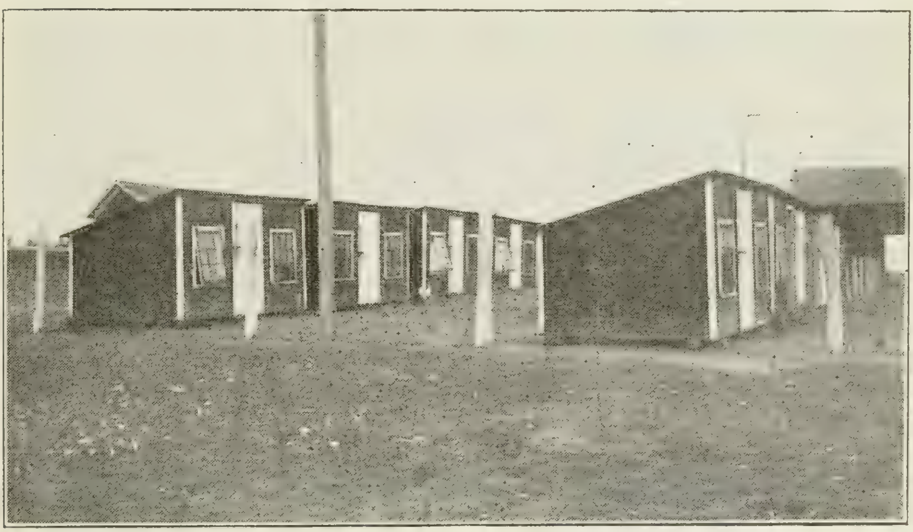


Fig. 18. Portable colony houses may be used as breeding pens.

PORTABLE COLONY HOUSE.

Figures 15 and 16 are drawings of a portable colony house which has a universal use, being suited for brooding early chicks, when fitted up with Universal Hovers or indoor brooders. (See also Figs. 2, 4, 17 and 18.) It may be used as a colony house on the range for growing chicks during the summer, or as a special pen for breeding hens in the early spring. The house is seven and one-half feet by twelve feet. It is built on runners four inches square, extending lengthwise of the building. Pieces of two by four inch material are placed on edge for joists four feet apart, and the floor is then laid before the frame work is constructed. The studding is then toenailed to the floor, being six feet long in front, and four feet in the back, and placed three feet apart. Two by four inch pieces are used as plates. Figure 16 shows the location of the door and windows in the front of the colony house. The door in the center is 2 feet 6 inches by 6 feet. On each side of the door is a 9 light, 8 by 10-inch glass window, hinged at the top to swing out and fitted in a way to permit its removal in summer. The house can be easily hauled from one location to another, largely eliminating the question of yarding young chicks, and making the summer care of growing chicks comparatively easy.

CONCLUSION.

Simplicity of construction, economy of building material, efficiency of ventilation and lighting, with due regard to location and dryness are the essential points to be considered in building a poultry plant. All fixtures should be movable and simple in construction, being so placed as to utilize the least possible amount of floor space. Feed boxes, hoppers, nests, etc., should have sloping tops and windows should be arranged in a way to prevent birds from roosting in objectionable places. A little forethought in planning will make the house much more satisfactory and convenient.

FOREWORD.

Bulletin No. 267.

This bulletin is a companion to number 260, published March, 1910, which is entitled *Seeds of Michigan Weeds*, and the two can profitably be studied together.

The aim has been not to repeat much that has been so recently published.

Very nearly all the drawings were made by F. Schuyler Mathews of Cambridge, Massachusetts. Figures 2, 3, 4, 4a, 8, 10, 11, 12, 16, 19, 20, are taken from Bulletins by the U. S. Dept. of Agriculture.

I am indebted to Dr. B. L. Robinson and M. L. Fernald of the Gray Herbarium of Harvard University for valuable hints and access to numerous herbarium specimens.

In all the plans made for extermination of weeds do not forget that when buried in the soil, a portion of the seeds of many weeds will retain their vitality for 30 years at least.

Two numbers are given to most of the illustrations, the one in parenthesis is the number corresponding to that of the cut in bulletin 260.

In the study of weeds as in the study of other plants it is well to group them according to some of their points of agreement.

In this treatise, I have given a brief popular account of each family that contains one or more weeds here illustrated.

Placing these cuts one to three to the page according to shape and size makes it impossible in many cases to arrange the species in approved sequence. In spelling and capitals I follow Gray's Manual, 7th Edition.

In the back part of the bulletin are duplicate copies of the decimal scale that any one can cut out and use for a measure, though these figures are not all natural size.

W. J. BEAL.

OBJECT OF THIS BULLETIN.

This bulletin is not intended as a full text concerning weeds and remedies for disposing of them; the chief object is to furnish illustrations that will aid students in school and college, and farmers out of school to recognize some of the more striking weeds.

The descriptions are purposely short and mostly popular. The botanist will not need the text, but will consult a reliable text book such as *Gray's Manual of Botany, 7th Edition.* The person not trained in botany will get little from the text. In case of the "pictures," in many cases they will not be very satisfactory to the uninitiated.

I hope that bulletin No. 260 and the present one will induce a few farmers at least to adopt better methods.

While I cannot predict what new weeds may be introduced, thrive and spread in Michigan, I have included several not yet prominent because of their bad record in near-by regions.

No person can know better than I do the very rapid increase in the number of weeds on Michigan farms. As a rule each farm is annually getting more sorts of weeds and as each farmer is cultivating weeds, these are becoming more freely distributed in every field and along every roadside.

EXPERIENCE OF THE GERMANS AND ENGLISH.

What has been the experience of older countries, such as Germany and Great Britain? Previous to 1860, it was a very common practice to mix old seeds with new of the same variety. The old seeds will not grow, or most generally if they do grow they produce inferior plants. Another common practice is to kill seeds of charlock by boiling or baking, then assort the seeds into two sizes by means of a sieve. The larger seeds were used to mix with rutabagas, the smaller with turnip seeds. In such cases all the seeds which grow are good, but the purchaser is deceived in the quantity he buys and in the amount of which he sows on a given space. Old seeds, or seeds of another variety, were often dyed and used to adulterate good seeds of red clover and other species. Sulphur-smoking is often resorted to, to renovate the appearance of worthless old grass seed. Some seeds are dressed with oil for a similar purpose. There were many experts in the business who carried on a regular exchange in doctored seeds.

In a case in Germany, 59 per cent of seeds corresponded to the labels under which the articles were sold, and only 18.3 per cent were capable of germination. A sample of orchard grass contained 39 other species of seeds. In a sample sold for Meadow Foxtail, only one-half the seeds were of this species, and of the genuine seeds only 5 per cent were alive and capable of germinating, so that 100 lbs. of the seeds as sold furnished 50 lbs. of inferior, worthless, or injurious foreign seeds and only 2½

lbs. of seeds capable of producing plants of the species for which they were sold. All the samples referred to came from dealers who ranked among "the reliable" in Germany. In 1868 over 3 tons of so-called red clover seed were sold to farmers in the Saxon city of Chemnitz alone, of which two-thirds was yellow clover. Of 51 specimens of red clover seed, 31 were found to contain seeds of the dodder, "the destructive (parasitic) enemy of the clover plant." In another case, "of samples of timothy seed, the best yielded 99 per cent of sound seeds, the poorest 15 per cent, while the average was 82 per cent." To the tradesmen "troublesome questions are put if the seed is found better or worse one year than another," so they get accustomed to adulterating and keeping seeds of about the same average year after year. One advantage of using dead seeds is that they tell no tales in the shape of feeble plants, or of plants other than the variety desired. In Prussia at present, government experts are appointed to test seeds for merchants and for farmers and gardeners.

In Germany, one or more firms, formerly at least, ground up quartz, sifted it and colored it to resemble seeds of red clover, with which it was mixed. It requires close examination with a miscroscope to detect the quartz from the clover seed.

In 1869, it is estimated that in England alone, 20,000 bushels of poor turnip seed was sown mixed with good seeds. A few brief experiments will enable anyone to tell which seeds are dead and which will grow, but it requires more time to tell which are weak and which are strong, or to tell which are true and which untrue to the name put on the package.

There appeared at one time, and perhaps it still exists, an organized agreement among seedmen of England, with perhaps some exceptions, to adulterate certain sorts of seeds to just such an extent. Pure fresh seed they quote as "net seed," while dead seed is quoted as "tri" or "000." In some seasons they agree to adulterate cauliflower so that a package shall contain only 50 to 60 per cent of good seeds. At one time 18 packages of seeds of cauliflower were taken to contain from 86 to 24 per cent of good seeds, averaging 51 per cent; 18 samples of seeds of broccoli ranged from 86 to 35 per cent, averaging 51 per cent; 18 of carrot seeds ranged from 61 to 14, and averaged 40 per cent of good seeds. The same number of packages of white turnip seed ranged from 98 to 57, averaging 74 per cent of living seeds.

In Great Britain they now have a law passed making it a fine of not over five pounds for the first offense and fifty pounds for the second offense to dye or kill and sell worthless seeds. Besides the fine, the court has authority to advertise the name of the offender in any newspaper at the expense of the guilty party. No wonder those who manage farms in Germany, England and other old countries chafed under this imposition. They agitated the subject and began to enact laws with penalties attached to them. If I mistake not, the first seed-control station was started by Dr. Nobbe of Saxony in 1869 and many others have followed.

Adulterations of seeds were discovered most ingenious in character, harmful in effect, and remarkable in amount.

Since 1871, members of the Royal Agricultural Society of England have among their officers a consulting botanist, William Caruthers, 44

Central Hill, Norwood, London, S. E., who made his first report in 1872, and continued in service certainly until 1905. His successor is still acting in the same capacity. Members of the society can avail themselves of his advice by paying a small fee varying in amount according to the service rendered. Although but few farmers avail themselves of the advice of the consulting botanist, the purity and quality of grass seeds and those of other forage plants, rapidly improved, until today there is very little cause for complaint.

WEED SEEDS OFTENEST MET WITH IN CLOVER SEED.

In the year 1910, 122 lots of seeds of red clover were selected by our agent where offered by the merchant for sale. These were examined at the Agricultural College and 51 kinds of seeds of weeds were detected. Nine samples only of the whole number contained no weeds.

Seventy samples of clover seed contained seeds of *Setaria viridis* (green foxtail).

Sixty samples contained *Plantago lanceolata* (buckhorn).

Fifty-eight samples contained *Plantago Rugelii* (Rugel's plantain).

Fifty samples contained *Rumex crispus* (narrow-leaved dock).

Forty-six samples contained *Rumex Acetosella* (sheep sorrel).

Thirty-six samples contained *Polygonum Persicaria* (lady's thumb).

Thirty samples contained *Chenopodium album* (lamb's quarters).

Twenty-three samples contained *Plantago major* (one of the broad-leaved plantains).

Twenty-three samples contained *Echinochloa crus-galli* (barnyard grass).

Twenty-one samples contained *Ambrosia artemisiifolia* (common ragweed).

Seventeen samples contained *Panicum capillare* (hair grass).

Sixteen samples contained *Digitaria sanguinalis* (crab grass).

Fifteen samples contained *Potentilla monspeliensis.*

Fourteen samples contained *Amaranthus retroflexus* (our most common rough pigweed).

Thirteen samples contained *Lepidium virginicum* (one of the pepper grasses).

Nine samples contained *Setaria glauca* (yellow foxtail or pigeon grass).

Nine samples contained *Stellaria media* (our most common chickweed).

Eight samples contained *Nepeta Cataria* (catmint or catnip).

Seven samples contained *Lepidium apetalum* (a small pepper grass).

Six samples contained *Prunella vulgaris* (self heal).

Five samples contained *Cerastium vulgatum* (mouse-ear chickweed).

Four samples contained *Bromus secalinus* (common chess).

Three samples contained *Rumex obtusifolius* (broad-leaved dock).

Three samples contained *Anthemis Cotula* (Mayweed).

Three samples contained *Oenothera biennis* (evening primrose).

Three samples contained *Daucus Carota* (wild carrot).

Two samples contained *Digitaria linearis* (narrow-leaved panicum).

Two samples contained *Lithospermum arvense* (red root).

Two samples contained *Lolium perenne* (perennial rye grass).

Two samples contained *Portulaca oleracea* (purslane).

Two samples contained *Cichorium Intybus* (chickory).
Two samples contained *Brassica nigra* (black mustard).
Two samples contained *Cirsium arvense* (Canada thistle).
Two samples contained *Cuscuta arvensis* (dodder).
Two samples contained *Verbena urticifolia* (nettled-leaved verbena).
One sample contained *Medicago lupulina* (black medick).
One sample contained *Ranunculus bulbosus* (bulbous crowfoot).
One sample contained *Ranunculus repens* (creeping crowfoot).

NO VERY EASY WAY TO DESTROY.

The great mass of farmers and gardeners think to kill a weed by some royal easy process, such as mowing in a certain phase of the moon or a certain definite period in the year or by once or twice cultivating. After the cultivator he waits until the leaves are several inches high before making the next effort. Such persons will always have the company of a weed after its first introduction into his field or garden.

To kill countless thousands of weeds coming from seeds, cultivate the ground weekly during the growing season and do not permit the weeds to go to seed, or, if this is too costly, let the weeds have their own way except during the early growth of cultivated crops. Frequent cultivation is necessary to a first class yield.

TO KILL WEEDS IN A LAWN.

In case of weeds in a lawn, most of them may be kept in check by enriching the ground liberally, enabling the better grasses to thrive by "driving the weeds to the wall."

HOW TO DEAL WITH QUACK GRASS.

The following concerning quack grass, contains points that will apply to many other weeds.

I have long considered quack grass, *Agropyron repens*, the worst weed that vexes the tiller of the soil in Michigan. It is because it holds its own well and spreads whenever there is a chance, and chiefly because the farmer does not recognize it until it is scattered far and wide. It is carried by the plow, harrow, and cultivator from one end of the field to the other. To have a farm well seeded to this grass is a calamity to be avoided.

All that is *needed* to exterminate a field of quack grass *is the right kind of a man* who will carefully observe and study the plant, fighting with method and thoroughness.

I have killed 100 or more patches and can speak from practical results and success. *Plants of this sort cannot gain any if the green leaves are not allowed to appear. The nourishment stored in the white root stocks underground will aid the plant to send up slender leaves and if these remain, the plants gain and recruit, but if the leaves start underground and are cut off before coming to the light, these white rootstocks are drawn on again to furnish food to start more leaves and thus, in time become exhausted.* If convenient, pasture closely for a whole growing season which prevents the production of new thrifty rootstocks then, if the sod be well turned under deep, rolled and har-

rowed, much of the grass will be killed at once. Ordinarily I plow late in the fall or very early in spring, rain or shine, wet or dry, or even in June, and cultivate with a shovel-toothed cultivator every three days till the middle of June, or later if starting the work later. Rarely, if the weather be wet and hot, cultivate every two to two and a half days. Keep all green leaves from showing themselves. Do not delay to see green leaves. A harrow that does not cut off the stems below the surface of the ground is not efficient.

The worst luck I ever had in this work was in summer-fallowing a piece of quack grass during a dry year. A good deal of it remained dormant and grew the following spring.

One year I tried the application of salt on one side of the bank of a brook where cultivation was very inconvenient. The strip of grass was about four rods long and the slope about five feet. Whenever seen a little at a time two barrels of salt were freely applied for the whole growing season, and the next spring the grass started up in several places ready to continue the fight, which was abandoned on that line.

For five years I tried (on the banks of a brook, or where there were only small patches) the following scheme, with great satisfaction:

During the wet and growing part of a summer I put on tarred building paper, taking care to have it overlap and completely exclude every ray of light. Six weeks to two months is enough, possibly four to five weeks, if the weather is hot and wet.

Very likely the reader will think this method costly and will hesitate and dally along, giving the grass a good chance to extend its domain. It is not worth while to plow deep or rake out the rootstocks. It is much better to be thorough in spring during a growing time than during a drouth. I mean that it can be subdued faster in wet weather than in dry. When very dry the underground stems remain dormant. Of course, small patches can be dug over with a hoe.

Where one is neat and thorough he may prefer to take two or three years in the extermination, growing two or three crops of corn in succession.

With all the talk about the importance of sowing clean seeds, the killing of weeds by a rotation of crops, the value of plow, cultivation, harrow, mower, rake, hoe, spade, urgent appeals come from the man whose field of oats is yellow with the flowers of mustard or whose lawn is yellow with dandelions.

He seeks information regarding

THE SPRAYING WITH CHEMICALS.

In the absence of long continued and thorough experiments at this college in spraying weeds, I quote from bulletin 80, 1908, of the Experiment Station, North Dakota, where Professor H. L. Bolley began this kind of work in 1896 continuing ever since for fourteen years. After all, he "Is not over sanguine in this matter, still the proper handling of spraying machinery and proper spraying at the proper time gives splendid results in weed destruction without material injury to growing cereals, to grass of the pasture lands or to lawn grasses.

"In many places it is difficult to secure good apparatus at reasonable prices. Again, it is difficult to convince some that the cheap potato

sprayer, which has no power capacity, cannot be made to serve the purpose.

"For use in grain fields, the cart should be fitted with a pole for two or more horses. The wheels should be of low form and have wide tires, 3½ to 4 inches. For work on small farms the tank should hold at least 52 gallons.

"All parts in contact with the solution should be either wooden, brass or rubber. Even galvanized iron is readily destroyed by the solutions used to eradicate weeds.

"The spray beam should carry nozzles sufficient to throw in a forceful, misty spray from one to one and one-fourth barrels of liquid for each acre of ground. The pump should give a pressure of about 100 or more pounds per square inch, shown by a gauge attached. Many questions are involved. The abundance and the sturdiness of the crop and the weeds; the climate, the growing season; whether the weeds are growing in dense, persistent clumps, such as Canada thistles, and whether it is important to undertake to save the crop in the particular spots or not. Do not buy patent or highly advertised chemical-weed eradicators, but instead buy chemical substances on the market.

"The station has used, successfully, in various sorts of weed-eradication work, common salt, iron sulfate (copperas, green vitriol) copper sulfate. (blue stone of blue vitriol), corrosive sublimate (mercuric bichloride) and sodium arsenite ($NaAs\ O_2$). Great care should be taken in using some of these.

"This chemical method of weed eradication has the peculiar merit that the weeds may be attacked while a crop is being grown and the crops will still give an increased yield. 'Chemicals act differently upon the members of different families of plants.'

"One field sprayer, with proper help, can spray from twenty-five to forty acres per day.

"Good field sprays cost from \$60 to \$150. Good hand sprayers, for dandelions and patches of Canada thistles, etc., may be had at \$8 to \$10. Iron surfate in powdered form, ready for use in solution, was available in Grand Forks and Fargo for .90 to \$1.10 per hundred pounds.

"The question as to when to spray must be settled by a number of considerations, crop conditions, the weed growth, and weather.

"Good results have been obtained in spraying oats, wheat and barley when the grain is eight to twelve inches high, to kill mustard and king head (giant ragweed). Mustard is most easily killed when it is just beginning to blossom, though iron sulfate is effective against this weed at all stages up to the forming of seeds.

"The most effective spray for Canada thistle is sodium arsenite at the rate of 1½ to 2 pounds per 52 gallons of water. The next most effective spray is common salt at the rate of one-third to one-half barrel to 52 gallons of water, in either case to be used where the thistles are in compact masses.

"In fighting the dandelion by means of chemical sprays, late experiments indicate that spraying will eventually give marked success, by using iron sulfate, spraying once a month. Plantain also gradully dies out under the spraying. For ordinary lawn purposes the ideal appa-

ratus is the compressed air type of hand spraying machine, keeping up a fine spray under high pressure, using two-pounds of iron sulfate for each gallon of water, or a weaker solution, one and one-third to one gallon of water. Do not spray until two or three days after cutting and then wait two or three days before cutting again. Spray on bright days. As seeds are blowing about a total and permanent eradication cannot be expected.

"Spraying has destroyed the following weeds; False-flax, worm-seed mustard, tumbling mustard, common mustard, shepherd's purse, pepper-grass, ball-mustard, corn cockle, chickweed, dandelion, Canada thistle, bindweed, plantain, rough pigweed, rag-weed, cocklebur.

"The writer wishes to emphasize two points: After killing most of the dandelions, do not neglect to add seeds of June grass and keep fertilizing the lawn, as dandelions seldom do harm where the grass is thick."

MICHIGAN WEEDS.

Fig. 1 (1.)

ASCOMYCETES.

Ergot. Spurred Rye. *Claviceps purpurea* (Fr.) Tul. Fungi bearing spores produced in definite number (often 8) in specialized cells, asci.

This is a poisonous fungus sometimes appearing on the grains of rye, timothy, red top and other grasses and is mentioned here because its nature is frequently misunderstood.

About fifteen of these growths are here represented as projecting from a spike of meadow foxtail and four large growths from a spike of rye. This is only the first stage of the fungus, of which there are several others not represented, appearing the following year.

GRASS FAMILY. GRAMINEAE.

There are many widely different plants which in popular language have the name "grass" attached to them, such as knot-grass, rib-grass, cotton-grass, sea-grass, eel-grass, sedge-grass, the clover and others, but these do not belong to the family here under consideration.

Grasses which are grown chiefly for the use of their grain, such as Indian corn, wheat, oats, barley, rye, rice, doura are called cereals.

Besides the cereals the family includes sugar cane, millet, bamboo, timothy, red-top, June grass, fowl meadow grass, blue joint, buffalo grass, orchard grass, meadow foxtail, the fescues, rye-grass, oat-grass, Bermuda grass, and other pasture grasses, and, as will here be seen, the family is conspicuous for a considerable number of weeds.

The grass family heads the list of food producing plants, which are the foundation of all agriculture. Of the staple crops of the United States, the grass family contributes about five-sixths of the total value. There are about 3,500 species of grasses.

Fig. 2 (2).

Quack Grass. Couch Grass. *Agropyron repens* (L.) Beauv. A mooths pale green perennial, very variable, 30-120 cm. high, with long creeping, jointed rootstocks; spikes 6-20 cm. long, erect or bent; spikelets 10-20 mm. long, 2-8-flowered, florets overlapping for three-fourths of their length or more; empty glumes each unsymmetrical, 7-11 mm. long, first strongly 5-6-nerved, second 7-8-nerved, acute or notched, margins scarious, floral glume about 1 cm. long, those above shorter, 5-nerved near the short awned apex.

Found in Europe, North Africa, Asia and extensively naturalized in cultivated grounds in North America. The rootstocks fill the soil, much resembling those of June grass, except they are larger; the flat, twisted leaf-blades near the ground are not easily distinguished from those of timothy. It seldom produces seeds till the plants becomes dwarfed by crowding.

I have long considered quack grass the worst weed in Michigan because it holds its own well and spreads whenever there is a chance and chiefly because the farmer does not recognize it until it is scattered far and wide.

Fig. 3 (3.)

Wild Oat. *Avena fatua* L. This annual plant has much the appearance of the oats in cultivation, of which some consider this the parent form. The species has attached to the back of the floret a conspicuous awn, twisted and bent when dry, besides the firm floral glume is thinly clothed with stiff slender hairs, and these aid it much in distribution by adhering to the fleeces of animals and to the inside of grain sacks. Troublesome in Oregon, California, Canada and neighboring regions where cereals are extensively grown, but as yet seldom seen in Michigan. Introduced from Europe.

Fig. 4 (15).

Stink Grass. *Eragrostis megastachya* (Koeler) Link. (*E. major* Host. *E. eragrostis* (L.) Karst. *E. poaeoidis* Beauv.) A spreading and much branched annual, 10-25 cm. high, the leaves bearing glands that secrete a substance very offensive to grazing animals. Panicle ovoid or linear rather dense, 5-15 cm. long; spikelets flat, lead-colored, 8-20 flowered. Sandy waste places; introduced from Europe.

(Fig 4a.)

Eragrostis hypnoides (Lam.) B. S. P. (*Eragrostis reptans* Nees.) A light green prostrate, much branched and very variable annual, extensively creeping late in the season along ditches and wet land, 5-30 cm. high; spikelets flat, 10-40 flowered, borne on open panicles. Extensively distributed in the United States, Canada, Mexico and South America. The little thing seems to have no good common name.

Fig. 5 (5).

Fig. 6 (7).

Soft Chess *Bromus hordeaceus* L. (*Bromus mollis* L.) This plant is becoming frequent in waste places; an annual, 10-45 cm. high. The whole plant is soft hairy. Introduced from Europe.

Field Chess. *Bromus arvensis* L. and **Smooth Brome-grass.** *Bromus racemosus* L. Mentioned in Bulletin No. 260, are only rarely met with in this country. They have much the appearance of the common chess of our wheat fields, excepting the spikelets are softer and the awns longer. Some authors believe these three are mere forms of the same species. All of them are natives of Europe.

Chess, Cheat. *Bromus secalinus* L. Too common where it thrives with winter wheat, because like wheat, it needs to make some growth in autumn and matures in summer ready for harvesting and threshing with the wheat from which it is not easily wholly separated.

Specimens of this plant are occasionally met with in the field and harvested with red clover cut for seed. After threshing it goes with clover seed into a machine for a thorough rubbing which takes off some of the adherent inner chaff and often breaks off a little from one or both ends of the grain. Grains of chess thus mutilated are not uncommonly found mixed with clover seed and the two are sown at the same time. Introduced from Europe.

Fig. 7 (8).

Barren Brome Grass. *Bromus sterilis* L. A soft annual appearing in several places in the state, about 50 cm. high. The drooping spikelets are correctly shown at A. Introduced from Europe.

Fig. 8.

Downy Brome Grass. *Bromus tectorum* L. Stems erect, tufted, slender, 30-60 cm. high; leaves softly pubescent; panicle broad, one-sided, drooping, 6-15 cm. long; spikelets 10-20 mm. long.

Grand Rapids, Detroit, Bay County, spreading rapidly where introduced. Naturalized from Europe.

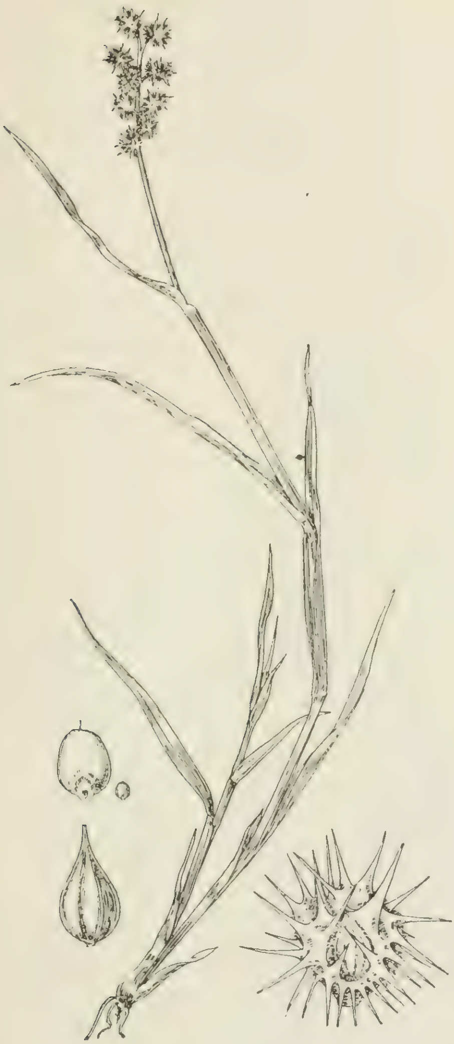


Fig. 9 (9).

Sandbur. Bur Grass. *Cenchrus tribuloides* L. Annual, with flattened spreading branches, about 30 cm. high. Each usually bearing 6-20, hard formidable burs inside of which the grains are produced.

The numerous, sharp diverging and minutely barbed prickles enable the burs to adhere to fleeces of animals and gain free transportation.

Sandy fields, borders of streams and lakes, widely distributed in North America and South America.

Fig. 10 (10).

Bermuda Grass. Scutch Grass. Dog's-tooth Grass. *Cynodon Dactylon* (L.) Pers. (*Capriola Dactylon.*) This grass-weed is a child of the sun and thrives all over hot countries, but at the same time it is a very valuable grass for pastures in the southern United States and is the very best thing to hold the fine soil on the artificial banks bordering the Mississippi.

The stems creeping on the surface and below are large, stout and wiry, making the land difficult to cultivate. In the southern states, Bermuda grass is the worst weed cotton growers have to contend with. In central Michigan the plant is killed back to the ground with the first hard frost, and during winter it is usually killed several inches below the surface. The succeeding year it starts with great deliberation, scarcely showing itself before July. Its season of about three months gives no promise of value for pasture in Michigan.

When everything is considered, I think quack-grass is one of the worst weeds that vexes the farmers of the state. In a number of places, I know Bermuda and quack grass have come in contact and both have attempted to occupy the same ground at the same time with the result that very little quack grass is left after Bermuda has once taken hold.

Fig 11 (11).

Small Crab-grass. *Digitaria humifusa* Pers. (*Panicum lineare* Krock. *Syntherisma linearis* (Krock.) Nash.) A smooth, slender annual with stems usually prostrate, spreading, 15-35 cm. high, each stem bearing 2-6 slender one-sided spikes. Whole plant of a reddish hue, not rooting at the nodes. Common in thin lawns and pastures late in the summer. Unless crowded the stems are prostrate. Introduced from Europe.

If lawns and meadows are enriched, the better grasses and clovers will crowd this plant out.

Fig. 12 (12.)

Large Crab-grass. Finger Grass. *Digitaria sanguinalis* (L.) Scop. (*Panicum sanguinale* L. *Syntherisma sanguinalis* (L.) Nash.) A spreading annual, often of a reddish hue, smooth or hairy, 30-60 cm. or more high, each stem bearing near the apex 4-15, one-sided spreading spikes, the stems usually sending out numerous tough roots at the joints. Common in gardens and often found in thin lawns and pastures. Introduced from Europe. If grass land is made rich, the better grasses and clovers will crowd this plant out, or nearly so.

Fig. 13 (13).

Barnyard Grass. *Echinochloa crus-galli* (L.) Beauv. (*Panicum crus-galli* L.) A coarse, erect or spreading annual, 30-120 cm. high. Spikes dense, alternate, simple or compound, 2-8 cm. long bearing spikelets on two sides of a three-sided rachis. Very variable in size and color. Waste grounds especially where moist, flowering all summer. Throughout the warmer regions of both hemispheres.

Fig. 14 (14).

Goose or **Yard-grass.** *Eleusine indica* (L.) Gaertn. A coarse, erect or spreading annual, 15-16 cm. high, each stem bearing at the apex or near it 2-5 diverging spikes, 5-7 cm. long. Rachis flattened. More common in tropical and warm temperate regions than in Michigan.

Fig. 15 (16).

Squirrel-tail Grass. *Hordeum jubatum* L. Other common names are Skunk Grass, Wild Barley. A smooth, slender, tufted annual, biennial or perennial, 30-45 cm. high. Spikes 4-7 cm. long, rachis very slender soon breaking at each joint the lower portion of which is barbed and sharp-pointed, making a formidable weapon to pierce the gums of cattle and sheep. The spikelets are three in a cluster each with two slender awns, 4-6 cm. long. Very graceful and ornamental before the spikes break in pieces. Native of this country and widely distributed. Fortunately seldom abundant except on moist alkaline soil. It yields readily to good cultivation.

Fig. 16 (19).

Low Spear Grass. *Poa annua* L. A soft, smooth, light green annual, stems weak, compressed, 5-30 cm. high. Panicle green or purplish. This grass will produce three crops a year in central Michigan. Found almost everywhere, in the vegetable garden and in a dense lawn. The enterprise of this little grass is equal to that of the English sparrow. Introduced from Europe. In shady places, where well fertilized and watered it produces a very pleasing lawn.

Fig. 17 (17).

Old-witch Grass. Tickle Grass. A Tumble-weed. *Panicum capillare* L. An erect, spreading, hairy, much-branched annual, 30-60 cm. high; bearing open panicles half the length of the entire plant. The branches very slender and rather stiff; the whole panicle when mature, breaking from the plant and carried for long distances by the wind. Native to this country.

Fig. 18 (18).

Switch Grass. *Panicum virgatum* L. The stem smooth, wiry, erect, 90-150 cm. high, usually forming large tufts, with creeping strong root-stocks, long, flat leaves and ample spreading panicles, sometimes 60 cm. long. Sandy soil, usually along lakes and streams. Extensively distributed in the United States and Mexico. Rather ornamental, seldom much of a weed in Michigan.

Fig. 19 (20).

Blue Grass. Flat-stemmed Poa. Wire Grass. Canadian Blue Grass. *Poa compressa* L. Bluish green, stems firm, smooth, much compressed, 30-60 cm. high from creeping rootstocks. Panicle usually contracted, 5-10 cm. long. Dry soil, extensively naturalized from Europe.

The "seeds" are sometimes used to adulterate those of June grass. Of the smaller details, perhaps the best single one to distinguish this grass from Kentucky blue grass is to be seen in figures of the spikelets, especially the palets.

Fig. 20 (21).

June Grass. Kentucky Blue Grass. Spear Grass. *Poa pratensis* L. A very common and variable widely distributed perennial; stems smooth, scarcely compressed, 10-120 cm. high, from copious running rootstocks; blades more or less compressed unless moist, 5-30, rarely 60-150 cm. long, the edges usually parallel, the apex very abruptly boat-shaped; panicle when open about as wide as high. Very extensively distributed in Europe, Asia, North and South America.

Our plants in cultivation introduced from Europe. This is one of our worst weeds for the garden and low moist fields in cultivation.

Fig. 21 (22).

Rye. *Secale cereale* L. An erect, glaucous fall annual, 1-2 m. high. Spikelets usually two-flowered, in a cylindrical spike, sessile, compressed, one at each joint on alternate sides of the rachis. A hardy plant, often a weed in fields of wheat. Introduced from Europe.

Fig. 22 (25).

Porcupine Grass. *Stipa spartea* Trin. A graceful, erect, tufted perennial, 50-120 cm. high. Leaves narrow, long acuminate, panicle few-flowered, 12-15 cm. long. Rather scarce in Michigan. A pernicious weed, on account of its barbed "seeds."

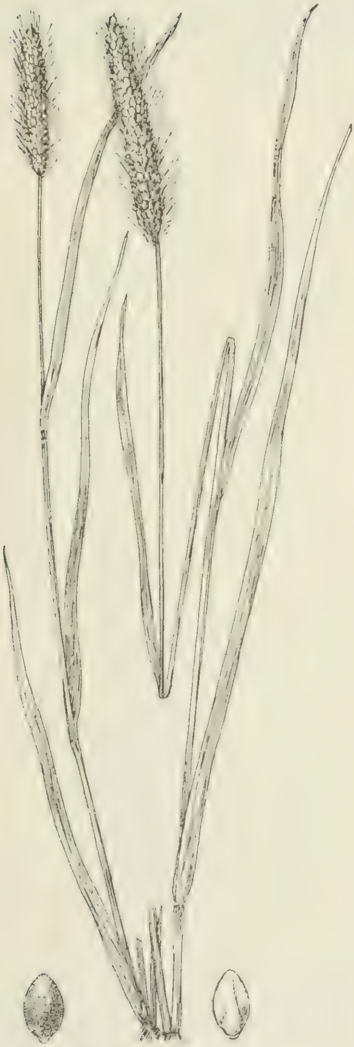


Fig. 23 (24).

Pigeon Grass. Green Foxtail. *Setaria viridis* (L.) Beauv. (*Chaetochloa viridis* (L.) Nash.) Stems erect, 30-60 cm. high. Sheaths not compressed, not tinged with red; blades flat, not twisted. Spike-like panicle erect, green, nearly cylindrical, 3-8 cm. long, bristles for each spikelet 1-5, often 10 mm. long, barbed upwards. Very common in cultivated fields, oftener met with in clover seed than any other weed. It much resembles small plants of Hungarian grass; naturalized from Europe.

Fig. 24 (23)

Pigeon Grass. Yellow Foxtail. *Setaria glauca* (L.) Beauv. (*Chaetochloa glauca* (L.) Scrib.) Stems erect, compressed below, 30-60 cm. high; sheaths loose, compressed, more or less tinged with red; blades flat twisted. Spike stiff, simple, cylindrical usually tawny yellow, 5-10 cm. high, awn-like branches, 6-13, barbed upwards.

A common annual weed found in cultivated ground and waste places in many regions of the world. It starts much later than our other species of pigeon grass, *S. viridis.* Introduced from Europe.

SEDGE FAMILY. CYPERACEAE.

A large family of grass-like or rush-like plants including about 3,000 species widely distributed over the world, nearly all of which are of little or no value to the farmer. Most of them thrive in marshes or on wet land. The leaves of sedges are placed one above or within the other on three sides of the stem, while the leaves on a straight stem of a grass plant are placed on two sides of the stem. Some sedges are cut and cured making hay of very poor quality, known as marsh hay.

Fig. 25 (26).

Yellow Nut Grass. *Cyperus esculentus* L. Sedges are very difficult of identification except by an expert. The cut gives a good idea of the top of a moderate sized plant, 30-70 cm. high. Perennial by rootstocks bearing tubers, one shown in the figure at b. Sometimes troublesome on low land. Remedy for the destruction of most all sedges is thorough drainage of the land.

Fig. 26 (27).

Ovoid Spike Rush. *Eleocharis ovata* (Roth.) R. & S. A slender, tufted annual, 6-40 cm. high; each stem bearing at its base several short leaf sheaths and at top a single egg-shaped spike, 2-7 mm. long. Very variable. Sometimes troublesome in wet land, as are also to some extent several other species much resembling this one, except in size and shape of the spike. Widely distributed. To get rid of it, drain the land.

RUSH FAMILY. JUNCACEAE.

This is a small family containing about 200 species of grass-like and sedge-like plants widely distributed, growing in tufts in moist land. (Fig. 27.)

LILY FAMILY. LILIACEAE.

Most people have some conception of the meaning of the word lily, though they may not recognize onions as members of the family. The world over there are 1,300 species in a restricted sense or nearly 1,900 in the broader sense. Botanists are not all agreed on this point.

Some people would rank leeks found in the woods in early spring as weeds, because they taint milk from which butter is made, though a few people like leeky butter. (Fig. 28.)

Fig. 27 (28).

Slender Rush. *Juncus tenuis* Willd. A small plant, 15-40 cm. high; stem wiry; the lower leaves about half as high as the stem; some of the upper leaves projecting above the flowers.

In dry or moist soil, especially along roads and paths, now spreading extensively in many regions. Seldom recognized.

Fig. 28 (29).

Field Garlic. Wild Garlic. Wild Onion. *Allium vineale* L. Like some other species this one not only produces bulbs in the ground, but in place of flowers at the top it has acquired the habit of producing bulblets more or less. The hollow stems are slender, a few in a bunch, 30-90 cm. high. Field garlic is slowly extending its domain into grass land and fields of wheat and is killed with much difficulty. The bulblets are about the size of kernels of wheat, and on this account are sometimes sown with seed wheat or ground in with the flour.

NETTLE FAMILY. URTICACEAE.

There are about 475 species of nettles and nearly related plants of wide distribution, mostly insignificant in appearance and economic value; all of them herbs, or, as some join the elms and mulberries with the nettles, the family then contains about 1,550 species.

Fig. 29.

Stinging Nettle. Great Nettle. *Urtica dioica* L. A rather stout, vigorous, stinging perennial, 60-90 cm. high; leaves ovate, heart-shaped, apex acuminate; flower clusters large, much branched, mostly dioecious. Waste places. Lansing, Bay City, Manistee. Introduced from Europe.

Fig. 30 (30).

Slender Nettle. *Urtica gracilis* Ait. A slender perennial, sparingly branched, 30-180 cm. high, armed with stinging hairs; leaves narrow, 5-10 cm. long. Moist soil, common.

BUCKWHEAT FAMILY. POLYGONACEAE.

Mostly herbs with entire leaves and stipules in the form of sheaths extending around the stem; flowers with a calyx more or less persistent; ovary one-celled, becoming an achene in fruit, flattened or 3-4- angled. Among its 800 species the family contains few of economic importance, but is rather conspicuous for the weeds it affords. Here are sorrels, docks, knotweeds, smartweeds and others.

Fig. 31 (31).

Knot-grass. Door-weed. *Polygonum aviculare* L. A slender, prostrate or erect annual (perennial farther south), dull or bluish green in color, usually less than 30 cm. high; leaves small; flowers small, inconspicuous; fruit a triangular achene, dull, minutely granular and striate. Common along paths and about door yards. Native to this country, Europe and Asia.

Fig. 32 (32).

Wild Buckwheat. Black Bindweed. *Polygonum Convolvulus* L. An annual, twining or trailing vine, 10-90 cm. or more long; leaves heart-shaped or halberd-shaped, pointed; flowers greenish in slender, interrupted racemes; fruit three-angled, dull, black; in cultivated annual crops. Introduced from Europe.

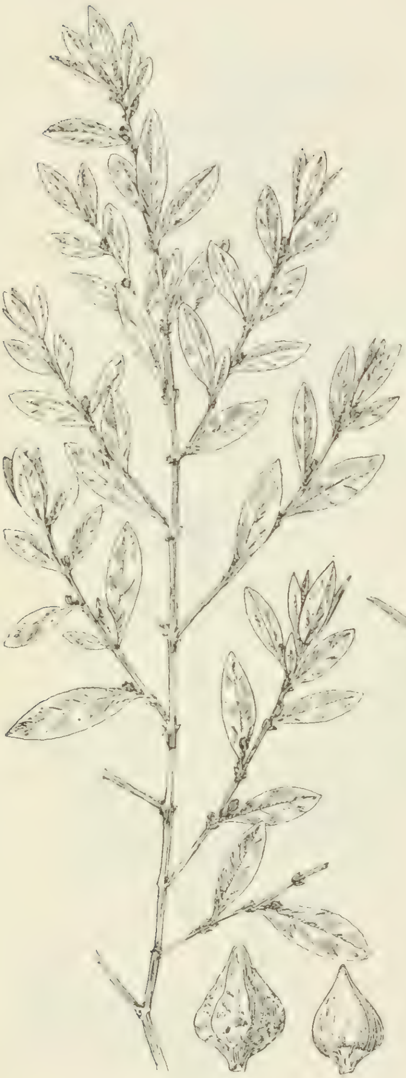


Fig. 33 (33).

Erect Knotweed. *Polygonum erectum* L. Annual, smooth, stem erect, usually simple; leaves oval, obtuse, 13-60 mm. long; flowers yellowish-green.

When compared with *P. aviculare*, it is taller with larger leaves and larger fruit. Seldom a weed of any importance; native of this country.

Fig. 34 (34).

Smart-weed. *Polygonum Hydropiper* L. A smooth, reddish, peppery, erect or spreading annual, 30-60 cm. high; leaves narrow, 2-8 cm. long; spikes nodding, interrupted, as long as the leaves; flowers mostly greenish; achene 2-3-sided, dull, granular. Wet land; introduced from Europe into this section; possibly indigenous in the northwest.

Fig. 35 (36).

Pennsylvania Persicaria. *Polygonum pennsylvanicum* L. Annual, smooth below, erect, simple or branched, 30-90 cm. high; peduncles and pedicels glandular; leaves lanceolate; racemes 2-4 cm. long; flowers bright rose-color; achenes flattened, nearly circular, jet black, about 3 mm. long. Moist soil; native to this country, Canada and the eastern United States.

Fig. 36 (35).

Pale Persicaria *Polygonum lapathifolium* L. Annual, smooth, the pedicels glandular, branching, 60-240 cm. high; leaves lanceolate, 4-20 cm. long; spikes slender, rather dense, drooping, 1-5 cm. long, achenes flattened, shining; wet places, common, very variable, throughout temperate North America. Introduced from Europe.

Fig. 37 (37).

Lady's Thumb. *Polygonum Persicaria* L. Annual, usually smooth much branched unless crowded, 15-60 cm. high; leaves lanceolate, roughish, often marked by a dark triangular or moon-shaped spot near the middle, giving rise to the common name, racemes dense, 2-3 cm. long; calyx pink to dark purple; achenes smooth, shining, usually flattened, 2-3 mm. long. Fields and waste places very common. Introduced from Europe and widely distributed.

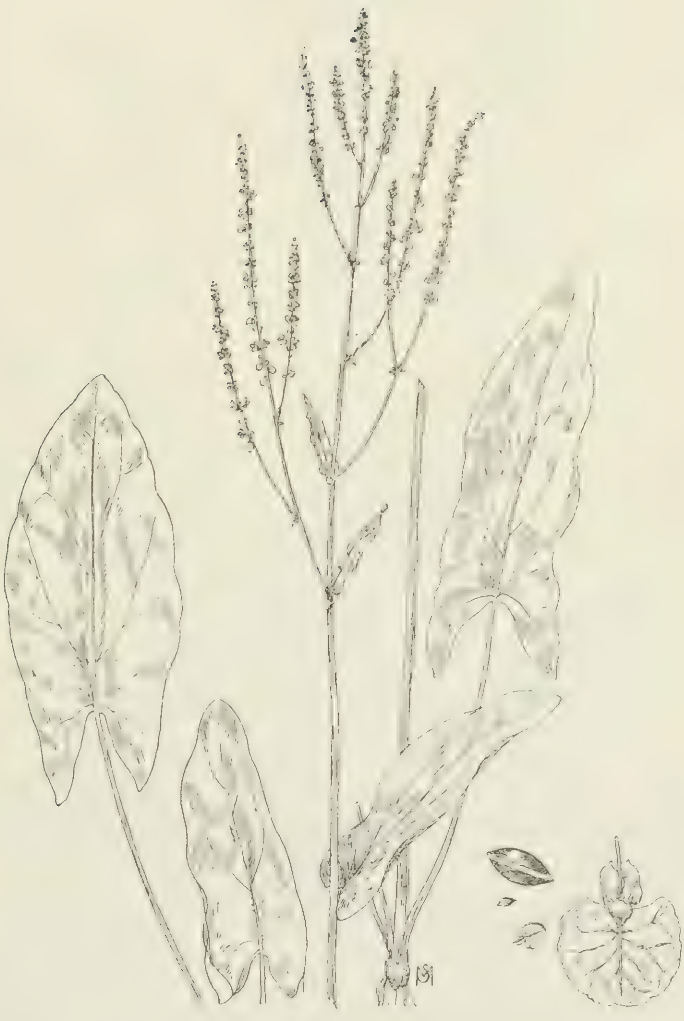


Fig. 38 (29).

Tall Sorrel. Sour Dock. *Rumex Acetosa* L. An erect, sour, smooth, dioecious perennial, 30-90 cm. high; spreading by rootstocks, leaves oblong, arrow-shaped, 2-10 cm. long; racemes erect, crowded or interrupted, calyx green, winged in fruit, orbicular, heart-shaped, 3.5-4.5 mm. long. Sparingly naturalized from Europe.

Fig. 39 (40).

Sheep Sorrel. Red-topped Sorrel. Field Sorrel. *Rumex Acetosella* L. An erect, sour, dioecious annual or perennial, spreading by running rootstocks, 10-30 cm. high; leaves mostly narrowly hastate, usually widest above the middle; flowers in erect, interrupted racemes.

Widely distributed throughout most of North America. Mostly introduced from Europe. In many places a common weed, though it is very scarce in cultivated land of the college farm.

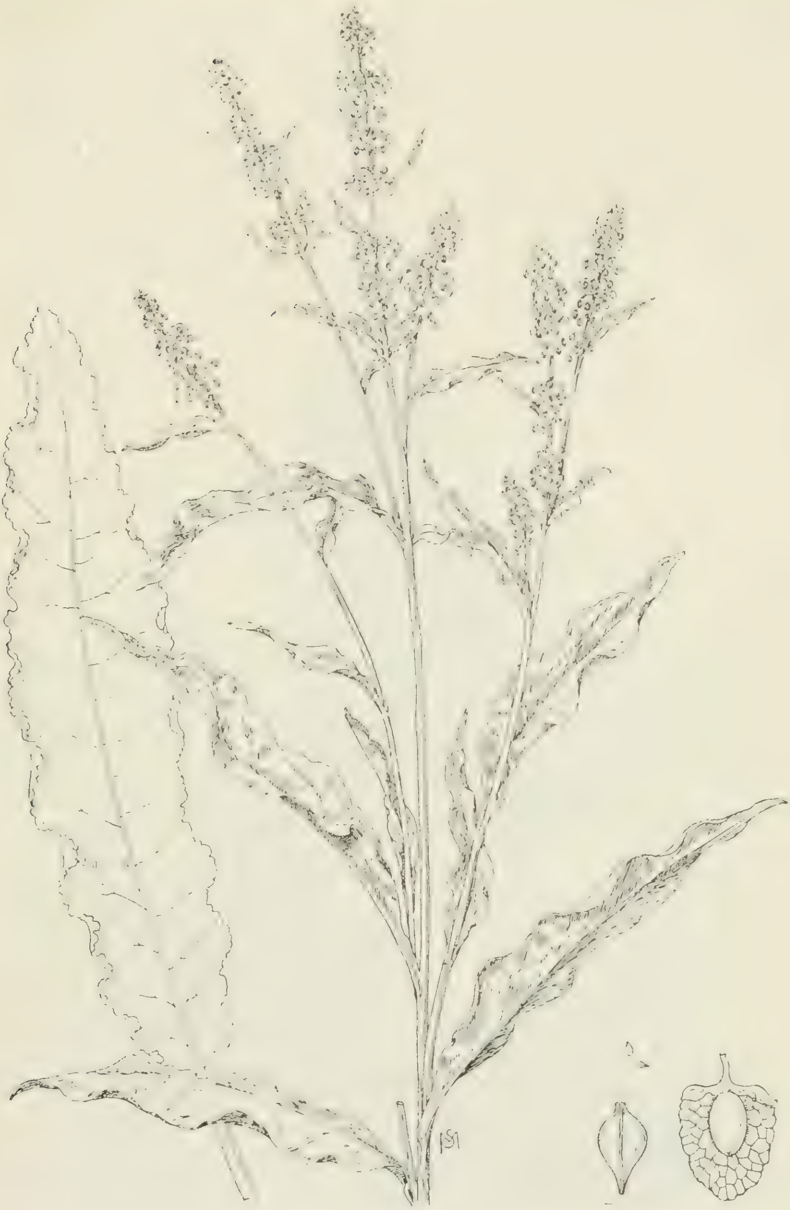


Fig. 40 (41).

Narrow-leaved Dock. Curled Dock. *Rumex crispus* L. Perennial with a deep tap root, smooth, rather slender, erect, 90-160 cm. high; leaf-blades cordate, lanceolate, acute, with wavy-curled margins; panicle rather open; flowers rather loosely whorled, valves circular, heart-shaped, nearly entire, 2.5-3.5 mm. long, each bearing a tubercle. Very common and well known as a bad weed. Introduced from Europe. Not difficult to manage with a good rotation of crops. When it appears in a meadow, wait till the stem runs up and gets some strength, before seeding. When the ground is soft, thrust a spade erect near the plant, prying with spade and pulling with the other hand and out comes all the main root.

Fig. 41 (44).

Willow-leaved Dock. *Rumex mexicanus* Meisn. (*R. salicifolius.*) A smooth, light green, erect, perennial, 30-90 cm. high, with a strong tap root; leaves linear-lanceolate; panicle very dense; calyx deltoid-ovoid; about 3 mm. long; tubercles three, large; achene dark red, shining. Native of North Eastern North America. Widely distributed, not yet common in Michigan.

Fig. 42 (42).

Broad-leaved or **Bitter Dock.** *Rumex obtusifolia* L. A smooth perennial, with a deep tap root; stem simple, stout, erect, 60-120 high; lower leaves heart-shaped, oblong-lanceolate, the upper narrower, the margins only slightly wavy; flowers loosely whorled, valves (part of calyx) ovate-hastate, with some teeth on the sides near the base, the larger tubercle ovoid-elliptical, the other two rudimentary; achene dark red, smooth, shining. Fields and roadsides, less common than *R. crispus*. Introduced from Europe and widely distributed.

Fig. 43 (43).

Patience Dock. *Rumex patientia* L. A tall, erect, perennial from a stout tap root, 60-150 cm. high; lower leaves ovate-lanceolate, long-petioled, 80-30 cm. long, the upper narrower; panicle dense, whorled; wings cordate, nearly entire, 4-9 mm. long, one tubercle, 2-3 mm. long, ovoid, the other two wanting or rudimentary. Becoming common; naturalized from Europe.

GOOSEFOOT OR PIGWEED FAMILY. CHENOPODIACEAE.

Chiefly annual herbs, of weedy aspect so far as this country is concerned; flowers very inconspicuous, each pistil bearing a single seed. Economic plants are spinach and beets. A small family of 550 species widely distributed.

Fig. 44 (45).

Spreading Orache. *Atriplex patula* L. A dark green, spreading annual 30-120 cm. high; leaves petioled, the blades narrowly lanceolate-hastate, 2-10 cm. long, sparingly toothed or three-lobed below; flower clusters in rather slender spikes, the two kinds together or separate. Naturalized from Europe. Not common nor troublesome.

Fig. 45.

Halberd-leaved Orache. *Atriplex patula hastata* (L.) Gray. A pale green or purplish, scurfy annual, 30-70 cm. high; leaves with slender stems, the blades of the lower broadly triangular-hastate, entire or sparingly toothed; very variable. Salt meadows and waste places along the Great Lakes. Not very troublesome.

Fig. 46.

Russian Pigweed. *Axyris amarantoides* L. A coarse, erect, branching, very leafy annual, 60-120 cm. high, clothed with short, star-shaped hairs, turning white with maturity.

Not yet known in Michigan but should be diligently looked for. Found near Winnipeg, Canada, as imported from Russia and is spreading rapidly.

Fig. 47 (46).

Pigweed. Lamb's Quarters. *Chenopodium album* L. Annual, pale green, branching much, 30-300 cm. high; leaves varying from rhombic-ovate to lanceolate, the lower more or less sinuate-lobed or toothed; flower clusters dense, simple or compound. Introduced from Europe and widely distributed in North America. One of our commonest weeds everywhere in annual crops. A variety, *viride* is bright green, less mealy and has less dense nflorescence, found with the above.

Fig. 48 (47).

Mexican Tea. *Chenopodium ambrosioides* L. A smooth or slightly glandular, not mealy, strong-scented, leafy annual, 60-90 cm. high; leaves with short stems, oblong-lanceolate, entire or wavy-toothed, spikes leafy, densely flowered. Naturalized from tropical America and widely distributed. Not prominent in Michigan.

Fig. 49 (48).

Jerusalem Oak. *Chenopodium Botrys* L. Annual, glandular, pubescent, viscid, strong-scented, 20-60 cm. high; leaves oblong, pinnatifid, 2-4 cm. long; racemes cyme-like, loose, leafless; flowers very small. Waste places, extensively spread, coming from Europe; not prominent in Michigan.

Fig. 50 (49).

Oak-leaved Goosefoot. *Chenopodium glaucum* L. Annual, spreading, 8-30 cm. high; leaves pale green above, white-mealy below, mostly oblong, sinuate-dentate, 24 cm. long; spikes small axillary. Often found in waste places over much of the globe, coming to this country from Europe.

Fig. 51 (50).

Maple-leaved Goosefoot. *Chenopodium hybridum* L. Annual, bright green, not mealy, 30-120 or more high; leaves thin, cordate, often ovate-rhombic, the lower, 8-15 cm. long, taper pointed, 1-4 large teeth on each side; racemes loosely panicled, leafless. Native to North America and Europe. Not a prominent weed in Michigan.

Fig. 52.

Nettle-leaved Goosefoot. *Chenopodium murale* L. Annual, scarcely mealy, loose, branched, 30-60 cm. high; leaves bright green with petioles, blades rhombic-ovate, coarsely and sharply toothed, 4-8 cm. long; spikes in loose axillary panicles. Widely distributed, coming from Europe. Not prominent in this state.

Fig. 53 (51).

Many-seeded Goosefoot. *Chenopodium polyspermum* L. Annual, not mealy, usually much-branched, 15-90 cm. high; leaves petioled, entire, mostly oblong, 2-6 cm. long; slender panicles abundant, calyx not completely covering the seed. Sparingly naturalized from Europe. Scarce in Michigan.

Fig. 54.

Upright Goosefoot. *Chenopodium urbicum* L. A dull green annual, scarcely mealy, 30-90 cm. high; leaves triangular, or narrowed at the base coarsely toothed, the larger, 6-10, cm. long; spikes erect, crowded in a long panicle. Naturalized from Europe. Not abundant. Waste grounds. Lansing, Ionia, Flint, Grand Rapids, Ann Arbor.

Fig. 55 (52).

Winged Pigweed. *Cycloloma atriplicifolium* (Spreng.) Coulter. A densely bushy-branched, pale green annual becoming purple, a tumbleweed, 10-40 cm. high; leaves petioled, blades lanceolate, sinuate-toothed, 2-6 cm. long; panicles loosely flowered. Occasional, coming from the west. Lansing, Port Huron, Manistee, Keweenaw County. May be expected wherever Russian thistles grow, as both follow railways, ballast of ships, and both are tumbleweeds.

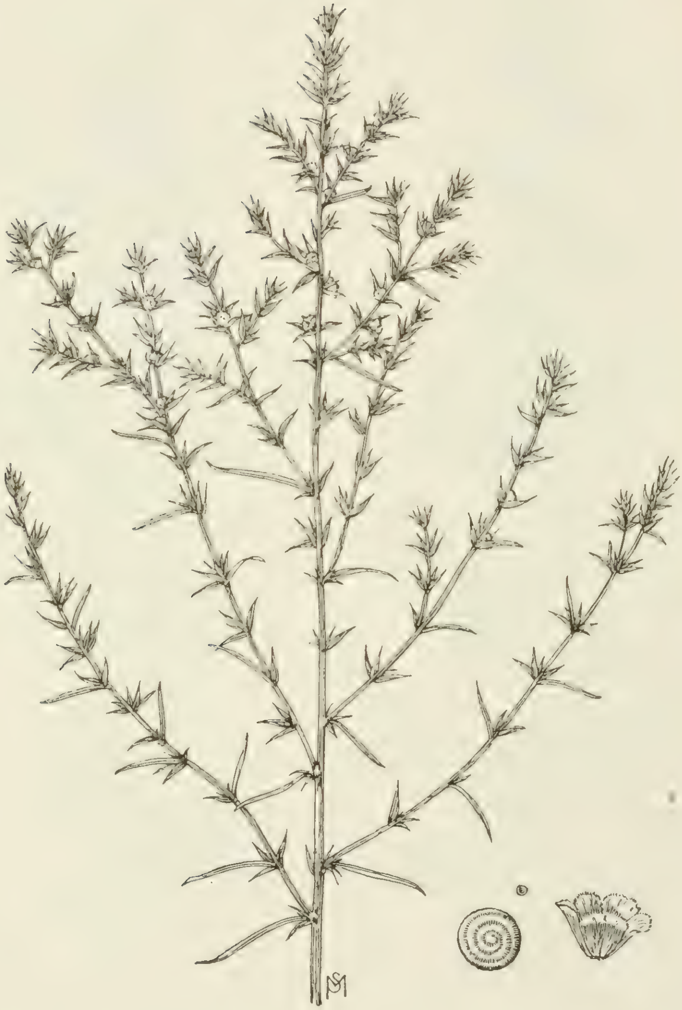


Fig. 56 (53).

Russian Thistle. *Salsola Kali tenuifolia* G. F. W. Mey. (*Salsola Tragus* L.) A dense bushy annual, 30-90 cm. high, a tumbleweed; young plants soft, succulent, bearing cylindrical leaves, 3-7 cm. long, relished by sheep; leaves of older plants awl-shaped, prickly-pointed; the whole plant streaked and splashed with bright red when mature. Especially troublesome in spring wheat and other annual crops. Introduced into the Northwestern States from Russia, and from there spread eastward carried by railway trains and mixed with seeds of alfalfa and red clover.

THE PRICKLY PIGWEEDS. AMARANTH FAMILY. AMARANTHACEAE.

Weedy herbs; flowers greenish-white, minute, surrounded by prickly bracts or scales, often colored. A small family including about 425 species, mostly growing in tropical regions.

Fig. 57 (54).

Western Water Hemp. *Acnida tuberculata* Moq. An erect, slender, dioecious annual, 30-90 cm. high; leaves lanceolate or rhombic-ovate, usually acute, 4-12 cm. long; spikes mostly loose or interrupted; flowers surrounded by soft prickly bracts. Frequent along the Grand River Valley. Native to this country.

Some plants of this species are prostrate but seeds of the prostrate do not all of them produce prostrate forms.

Fig. 58 (55).

Prostrate Amaranth. *Amaranthus blitoides* S. Wats. A smooth, pale green, much-branched, prostrate annual, 12-60 cm. or more long; leaves obovate or spatulate, 0.5-2 cm. long. In waste places, especially along railroads. Naturalized from the west.

Fig. 59 (56).

Tumble Weed. *Amaranthus graecizans* L. (*A. albus* L.) A smooth, pale green, bushy, branched annual, 30-60 cm. high; leaves oblong or spatulate, 0.5-1.5 cm. long; bracts awlshaped. Naturalized from tropical America, and widely distributed in North America. Sandy and gravelly, well drained soil, becoming when mature a model tumble weed.

Fig. 60 (57).

Green Amaranthus. Rough Pigweed. *Amaranthus hybridus* L. (*A. chlorostachys* Willd.) Usually slender, erect, dark green, nearly smooth, annual, 60-240 cm. high; leaves bright green both sides; spikes slender-cylindrical, bracts rather long. Cultivated grounds. Common east, but scarce in Michigan. Introduced from tropical America.

Fig. 61 (58).

Rough Pigweed. Red-root Pigweed. *Amaranthus retroflexus* L. Rough and more or less pubescent, rather light green, leaves long petioled, ovate or rhombic-ovate, wavy margined; spikes thick, crowded, stiff. Much like the foregoing species; the prevailing one in Michigan. Very common in annual crops of corn, beets, beans, potatoes. Introduced from tropical America.

Fig. 62.

Spiny Amaranth. *Amaranthus spinosus* L. A smooth, bushy-branched annual, 30-100 cm. high, considerably resembling *A. retroflexus*; leaves rhombic-ovate, dull green, differing from others described in having a pair of stiff spines at the base of each leaf. Common south, but rare in Michigan. Introduced from tropical America.

POKEWEED FAMILY. PHYTOLACCACEAE.

A single weedy plant, is native to the northern states. The small family contains about 85 species mostly native in the Tropics.

Fig. 63.

Pokeweed. Scokeroot. Pigeon Berry. *Phytolacca decandra* L. A tall, erect, smooth perennial, 1-1.5 m. high, tinged with red late in the season, roots large, fleshy, poisonous; leaves petiolate, oblong-lanceolate, acute at both ends; flowers in thin racemes, 4-16 cm. long; the berries dark purple, much liked by birds. Naturalized in Europe. Young shoots sometimes eaten like asparagus.

FOUR O'CLOCK FAMILY. NYCTAGINACEAE.

Mostly herbs, with simple, opposite, entire leaves and regular flowers; ovary enclosed in the base of a hardened calyx.

About 250 species of wide range, only two have been introduced into Michigan, besides the four o'clock sometimes cultivated.

Fig. 64.

Fig. 65.

Heart-leaved Umbrella Wort. *Oxybaphus nyctagineus* (Michx.) Sweet. (*Allionia nyctaginea* Michx.) Perennial from a stout tap root, nearly smooth; stem angled, repeatedly forked, 30-150 cm. high; leaves broadly ovate, heart-shaped, 4-8 cm. long; involucre next the flowers more or less persistent to aid in distributing seeds; sepals red. Introduced from the south and west.

Found at Richmond, Oakland county and at the Agricultural College.

Mentioned here because in the Botanic Garden, it behaves much like narrow-leaved dock, and is likely to become troublesome.

Hairy Umbrella-wort. *Oxybaphus hirsutus* Pursh, has been found at Grand Rapids. It differs from the preceding in being glandular-hirsute, leaves sessile, lanceolate, narrowed at the base, considerably resembling the preceding.

KNOTWEED FAMILY. ILLECEBRACEAE.

The plants of this small family much resemble those of the Pink family, and by many authors are placed in that family.

Fig. 66 (59).

Knawel. *Scleranthus annuus* L. A homely, light colored, much branched, little weed, 4-12 cm. high; leaves awl-shaped; flowers obtuse, seed held by the hard persistent calyx; having the appearance of a dry-ground chickweed.

Naturalized at the Agricultural College and at Ann Arbor. Introduced from Europe.

CARPET-WEED FAMILY. AIZOACEAE.

Mostly herbs, prostrate and branching, differing from purslane and the chickweeds by having the ovary two-several-celled, stamens and petals sometimes numerous. About 500 species, mostly of warm regions, only one having reached Michigan.

Fig. 67 (60).

Carpet-weed. Indian Chickweed. *Mollugo verticillata* L. A smooth, prostrate, much-branched annual, forming mats; leaves in whorls, spatulate. Introduced from farther south. Sandy fields and roadsides in the central and southern regions of the state.

PINK FAMILY. CARYOPHYLLACEAE.

This rather large family of herbaceous plants includes such a variety that it is difficult to define to any except botanists. It contains many sorts of pinks and carnations, and is one of the families abounding in weeds.

There are about 1,500 species, most abundant in the northern hemisphere, especially in Europe.

Fig. 68 (61).

Cockle. Corn Cockle. *Agrostemma Githago* L. A tall, silky, erect, fall annual; 30-90 cm. high; flowers large, red or pink, scarcely a weed except in fields of wheat; seed black, poisonous. Introduced from Europe.

Fig. 69 (62).

Thyme-leaved Sandwort. *Arenaria serpyllifolia* L. A light-colored annual, slender, much branched and spreading, roughish, 5-15 cm. high; leaf stems short, blades ovate, acute, 4-8 mm. long; flowers small, white, numerous. Sandy soil. Introduced from Europe.

Fig. 70 (63).

Larger Mouse-ear Chickweed. *Cerastium vulgatum* L. Annual or biennial, clammy-hairy, tufted, spreading, 15-40 cm. high; leaves mostly oblong, 12-20 mm. long; flowers small, white in loose compound cymes. Fields and gardens common. Introduced from Europe.

Cerastium arvense L. and its variety *oblongifolium*, also *C. viscosum* and perhaps other species are occasionally met with, but, as yet, they are of little importance.

Fig. 71.

White Campion. *Lychnis alba* Mill. (*L. vespertina* Sibth.) Biennial, loosely branching, glandular, hairy, 30-60 cm. high; leaves ovate to ovate-oblong, acute 2-6 cm. long; flowers few in loose panicles, white or pinkish, opening toward night, often dioecious; calyx tubular, enlarging in fruit; petals obovate, two-cleft, each with a ligule at the base of the blade.

Becoming common in the lower peninsula. Naturalized from Europe.

Fig. 72 (64).

Soapwort. Bouncing Bet. *Saponaria officinalis* L. Perennial, smooth, stout, sparingly branched, leafy, 30-50 cm. high; leaves opposite, ovate or oval, 3-5-ribbed, acute, 4-6 cm. long; flowers, pink or white in dense terminal cluster, sometimes double, calyx tubular, corolla about 2 cm. broad, petals obcordate, with a scale at the base of the blade; the mucilaginous juice forming a lather with water. Spreading from root stocks, common along roadsides and in waste places, especially in sandy land. Introduced from Europe.

Fig. 73 (65).

Cow-herb. *Saponaria Vaccaria* L. (*Vaccaria Vaccaria* (L.) Britton.) Annual, smooth, erect, sparingly branched, 30-80 cm. high; leaves sessile, opposite, ovate-lanceolate, 2-6 cm. long; flowers pale red, 30-40 mm. broad; fruit enlarged, five-ribbed. Occasionally a weed in fields of grain. Introduced from Europe.

Fig. 74 (66).

Sleepy Catch-Fly. *Silene antirrhina* L. A slender, erect, slightly-branched annual, 20-90 cm. high, when in flower glutinous along two of the upper internodes. Leaves linear or lanceolate, narrowed into a petiole; inflorescence, a loose, cymose panicle; flowers small, pink, petals obcordate with minute teeth at the base of the blade.

Native of this country. Poor sandy soil perhaps introduced with Timothy seed.

Fig. 75 (67).

Forked Catch-fly. *Silene dicholoma* Ehrh. Annual, erect, pubescent, 30-60 cm. high; leaves narrow; flowers white or pink, sessile or nearly so, in forked, one-sided spikes; calyx-ribs 5, hirsute.

Introduced with clover seed into several regions of the state and likely to be troublesome. It comes originally from Europe.

Fig. 76 (68).

Bladder Campion *Silene latifolia* (Mill.) Britten and Rendle. (*S. vulgaris* (Moench) Garcke, *S. Cucubalus* Wibel. *S. inflata* J. E. Smith.) A smooth, glaucous, spreading perennial, 10-20 cm. high; leaves opposite, ovate-lanceolate, variable in size; calyx globular, much inflated, petals two-cleft, white, 12-20 mm. broad.

Naturalized from Europe and becoming common in the state.

Fig. 77 (69).

Night-flowering Catch-fly. *Silene noctiflora* L. An erect, glandular, pubescent annual or biennial, 30-90 cm. high; lower leaves large and spatulate, the upper lanceolate, flowers in loose cymose panicles, fragrant, opening at night; calyx tubular, ten-nerved, enlarging in fruit; flowers few, petals two-parted, white or pinkish.

Common, seeds difficult to separate from clover seed. Introduced from Europe.

Fig. 78 (71).

Common Chickweed. *Stellaria media* (L.) Cyrill. (*Alsine media* L.) A weak, much-branched annual, 8-16 cm. high, smooth except hairs in lines on stem and petioles; leaves ovate or oval, the upper sessile; flowers in leafy cymes or solitary; petals white, two-parted. Introduced from Europe. Very common, especially abundant in spring and autumn when the weather is cool.

Fig. 79 (70).

Spurry. *Spergula arvensis* L. A bright green annual, 20-40 cm. high; leaves stipulate in whorls, thread-shaped, 2-5 cm. long; flowers white in terminal cymes.

Grain fields and waste places, especially in sandy land where some attempts were made to cultivate it in the northern portion of the lower peninsula. Naturalized from Europe.

PURSLANE FAMILY. PORTULACACEAE.

This small family of about 150 species consists of insipid herbs, mostly succulent and natives of America, of which one is a prominent well-known weed in Michigan.

Fig. 80 (72).

Purselane. Pussley. *Portulaca oleracea* L. Smooth, prostrate, spreading, succulent, extending in each direction, 10-30 cm.; leaves thick, alternate, clustered at the ends of the branches, obovate, 6-20 mm. long; flowers yellow, opening in sunshine for a short time in the morning. Native in the southwest. Introduced into the warmer portions of Europe.

CROWFOOT FAMILY. RANUNCULACEAE.

Mostly herbs of greatly diversified forms pervaded by acrid juice, a few woody vines; parts of the flower free and distinct from each other; some poisonous and used for medicine; in the north temperate zone a considerable number blossom in early spring, such as hepatica, anemone, butter cup, columbine, marsh marigold, globe flower, hellebore, rue anemone. About 1,050 species widely distributed, but few in tropical regions.

Fig. 81 (71).

Tall Buttercup or Crowfoot. *Ranunculus acris* L. Erect, hairy, perennial, 60-90 cm. high; leaves three-divided, each division three-cleft; petals yellow, shining. Fields and moist meadows and waste places, becoming common. Introduced from Europe.

Fig. 82 (75.)

Bulbous Buttercup. *Ranunculus bulbosus* L. Erect, hairy, perennial, 30 cm. high, from a bulb-like base; lower leaves three-divided, each three-parted, three-cleft and toothed; flowers shining, bright yellow, about 2 cm. broad. Very common in meadows in New England, slowly spreading in Michigan.

Fig. 83 (76).

Creeping Buttercup. *Ranunculus repens* L. Usually hairy, perennial, spreading by the rooting branches encroaching on grasses in meadows or lawns; leaves three-divided and variously cleft; flowers yellow, 2-2.6 cm. broad; seldom fruiting or fruiting sparingly. Introduced from Europe, perhaps indigenous in the west.

POPPY FAMILY. PAPAVERACEAE.

Herbs with milky or colored juice including poppies, bloodroot, celandine. A very small family widely dispersed in north temperate regions.

Fig. 84 (77).

Celandine. *Chelidonium majus* L. Perennial herbs, with saffron-colored acrid juice, 30-60 cm. high leaves variously divided and cut-lobed; flowers small, yellow, often double; fruit linear-cylindric, opening by two valves, 2-5 cm. long. Naturalized from Europe.

Fig. 85.

Poppy. *Papaver Rhocas* L. Becomes a weed in some places, but is not difficult to subdue. The same may be said of *Papaver dubium* L.

MUSTARD FAMILY. CRUCIFERAE.

Herbs with a pungent acrid juice (horse-radish), sepals 4, petals usually 4, the upper portion spreading in the form of a cross; stamens usually six, four longer than the other two, pod usually two-celled by a very thin vertical partition. Seeds of many species become mucilaginous when soaked in water.

There are about 1,500 species, most abundant in temperate regions. The family is easily recognized, but the species are difficult to determine.

Useful plants of the family are the cabbage, cauliflower, turnip, ruta baga, radish, rape, sweet alyssum, stock and a few others. Weeds in this family are abundant and aggressive, new ones arriving one or more each year. It ranks as one of the prominent weed-families. None is poisonous.

Fig. 86 (78).

Yellow or Small Alyssum. *Alyssum alyssoides* L. A small annual, 10-25 cm. high, appearing gray owing to immense numbers of star-shaped hairs on the surface; leaves mostly spatulate, entire; flowers yellow; fruit flat, nearly circular. Seldom prominent as a weed.

Fig. 87 (79).

Yellow Rocket. Winter Cress. *Barbarea vulgaris* R. Br. (*Barbarea Barbarea* (L.) Mac. M.) A smooth, erect, perennial, 30-60 cm. high; lower leaves with petioles, the blade lyrate-pinnatifid; flowers bright yellow, abundant; pod obscurely four-angled. Introduced from Europe. Rather frequent along ditches and low land. Often sent in for name, but so far not aggressive.

Fig. 88 (80).

Hoary Alyssum. *Berteroa incana* (L.) DC. a pale green, diffuse annual, 30-60 cm. high, thrifty, prolific and aggressive; leaves lanceolate or oblong; petals white, divided, pod oblong, plump, 2.5-3.5 mm. long.

Introduced from Europe, very recently found in Michigan, where it should be looked after without delay.

Fig. 89 (81).

Charlock. *Brassica arvensis* (L.) B. S. P. (*B. Sinapistrum* Boiss.) An erect, branching, hispid annual, 30-90 cm. high; lower leaves with petioles pinnatifid; flowers yellow, pod 4 cm. long, tipped with a flattened, elongated-conic beak, sometimes one-seeded. Difficult to identify; one mustard is about as bad as another; compare the apex of the pod and the seeds. Introduced from Europe.

Fig. 90 (82).

Rutabaga. *Brassica campestris* L. Smooth or sparingly hairy annuals, 30-90 cm. high; lower leaves petioled, others clasping at the base; flowers bright yellow; pod tipped with a beak. Study and compare the beak and seeds with other species. From Europe, an occasional weed.

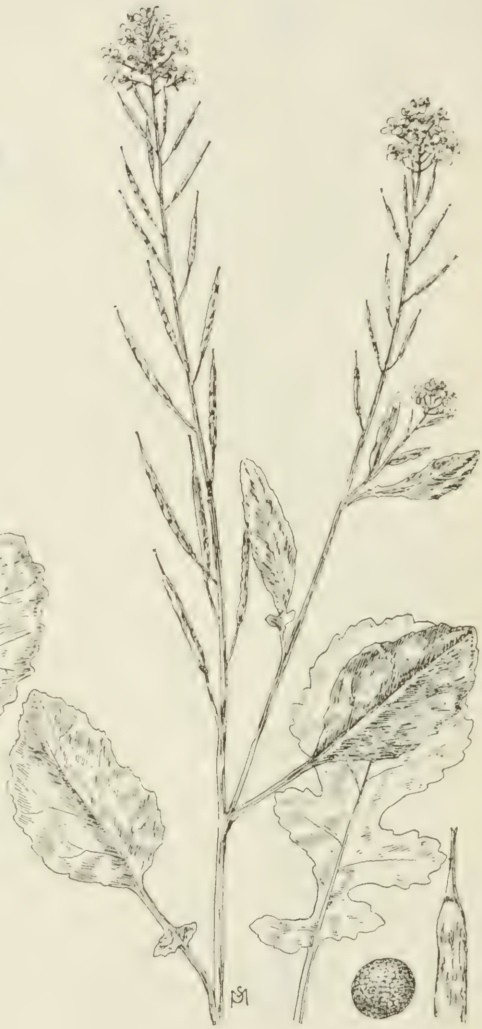


Fig. 91 (83).

Indian Mustard. *Brassica juncea* (L.) Cosson. An erect and branching annual more or less pubescent, 60-120 cm. high, lower leaves petioled, lyrate-pinnatifid; flowers yellow; pods 1.5-1.8 cm. long on short erect pedicels, oppressed, four-sided, beak 2-4 mm. long. Introduced from Europe. Compare beaks and seeds and the figures here represented. A bad weed, often confused with two, three or more others.

Fig. 92 (84).

Black Mustard. *Brassica nigra* (L.) Koch.
Notice the short pod with short abrupt beak. A common weed and aggressive.

Fig. 93 (85).

Small-fruited False Flax. *Camelina microcarpa* Andrz. Annual, 30-60 cm. high; plant more slender than those of the other species; upper leaves auricled, flowers yellow; pods smaller. 4-5 mm. broad.

Introduced from Europe, becoming common in Michigan.

Fig. 94 (86).

False Flax. *Camelina sativa* (L.) Crantz. Annual, 30-60 cm. high, lowest leaves petioled, entire toothed, 4-6 cm. long, upper leaves clasping, sagitate; flowers yellow, pod obovoid, margined, very slightly flattened, 6-8 mm. broad.

Fig. 95 (87).

Shepherd's Purse. *Capsella Bursa-pastoris* (L.) Medic. A fall annual, or annual, erect, branching, 15-40 cm. high; lower leaves variously pinnatifid, forming a rosette, stem leaves few, sagittate; flowers in racemes, white; fruit flat, triangular, about 5 mm. across. Naturalized from Europe and very widely distributed. Extremely variable.

43

Fig. 96 (88).

Hare's-ear Mustard. *Conringia orientalis* (L.) Dumort. A smooth, slightly succulent annual, or fall annual, 30-120 cm. high; leaves fleshy, sessile, entire, flowers creamy white; pods erect, square, 7-10 cm. long.

Rapidly spreading in northwest British provinces; sparingly introduced into Michigan, originally from Europe.

Fig. 97 (89).

Sand Rocket. *Diplotaxis muralis* (L.) DC. Annual, smooth or nearly so, branching from the base, 30-60 cm. high; leaves oblong, toothed or pinnatifid; flowers yellow, pods erect, linear, terete.

Introduced from Europe, and where it has been found in Michigan, thrives and spreads at an alarming pace.

Fig. 98 (90).

Worm-seed or **Treacle, Mustard.** *Erysimum cheiranthoides* L. An erect, minutely-rough, annual, or winter annual, 20-60 cm. high; leaves lanceolate, entirely or slightly dentate, 2-8 cm. long, the lower with slender petioles, the upper sessile; flowers yellow, pedicels spreading at about 45 degrees, the pods not quite erect, but taking on uniform positions, four-angled, smooth, 1-2 cm. long.

Probably native to some portions of the north central states and Canada.

Fig. 99 (91).

Apetalous Pepper-grass. *Lepidium apetalum* Willd. Annual or winter annual, more or less hoary, racemes properly branched, lower leaves pinnatifid; petals wanting, or only two minute, and white; pod flat, more or less circular.

Waste places, seldom causing much trouble; when ripe becoming a tumble weed.

Fig. 100 (92).

Field Pepper-grass. Cow Cress. *Lepidium campestre* (L.) R. Br. A diffuse, hoary-pubescent biennial, 10-30 cm. high; stem leaves sessile with an arrow-shaped base; flowers white or yellowish; pods flattened, more or less circular.

Fields and waste places, naturalized from Europe.

Fig. 101 (93).

Hoary Cress. *Lepidium Draba* L. An erect or ascending, hoary perennial, 20-35 cm. high; leaves oblong, entire or dentate, the lower petioled, flowers white; pods flat, broadly ovate.

Introduced from Europe, infrequent in Michigan.

Fig. 102 (94).

Garden Cress. Golden Pepper-grass. *Lepidium sativum* L. A smooth, branching annual, about 30 cm. high; lower leaves two-pinnate; flowers white in long loose racemes, pod flattened, oval.

Introduced from Europe and escaped from cultivation.

Fig. 103 (95).

Wild Pepper-grass. *Lepidium Virginicum* L. A diffuse annual or fall annual, 20-40 cm. high; lower leaves obovate in outline, usually with a large terminal lobe; stem leaves lanceolate, dentate; flowers white; pod flat, nearly circular.

Common in waste places, sometimes a tumble weed; native to this country and introduced into Europe.

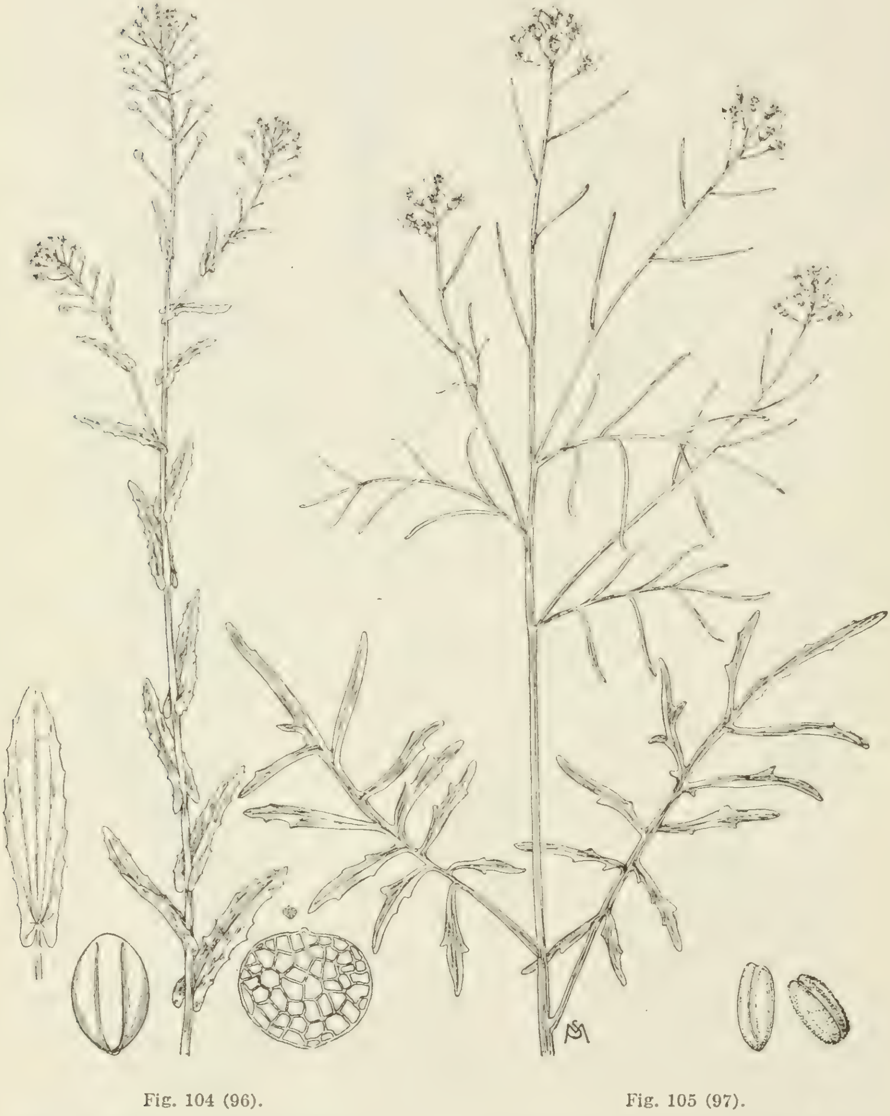


Fig. 104 (96).

Ball Mustard. *Neslia paniculata* (L.) Desv. A slender, branching annual, pubescent with star-shaped hairs, leaves oblong, sagittate; flowers in racemes; pods nearly spherical, 2-3 mm. in diameter.

Introduced from Europe into British Provinces of the northwest where it is very aggressive and may soon find its way to Michigan.

Fig. 105 (97).

Tumbling Mustard. Tall Mustard. *Sisymbrium altissimum* L. An erect, smooth, branching annual, 60-120 cm. high; leaves deeply pinnatifid; flowers pale yellow; pods narrow, stiff, diverging, 5-10 cm. long; seeds minute and enormously abundant; when mature the plant loosens from the soil becoming a first-class tumble weed; not yet abundant in Michigan but will soon become so.

Naturalized from Europe, with all the bad characteristics of a mustard.

Fig. 106 (98).

Hedge Mustard. *Sisymbrium officinale* (L.) Scop. A rather stiff, slender nearly smooth biennial, 30-90 cm. high; leaves pinnatifid; flowers small, yellow; pods narrow, stiff, closely pressed to the stem. Not a vicious but a homely weed. Introduced from Europe.

Fig. 107.

Green Tansy Mustard. *Sisymbrium incisum* Engelm. Is causing trouble in the Canadian northwest and may be expected in Michigan.

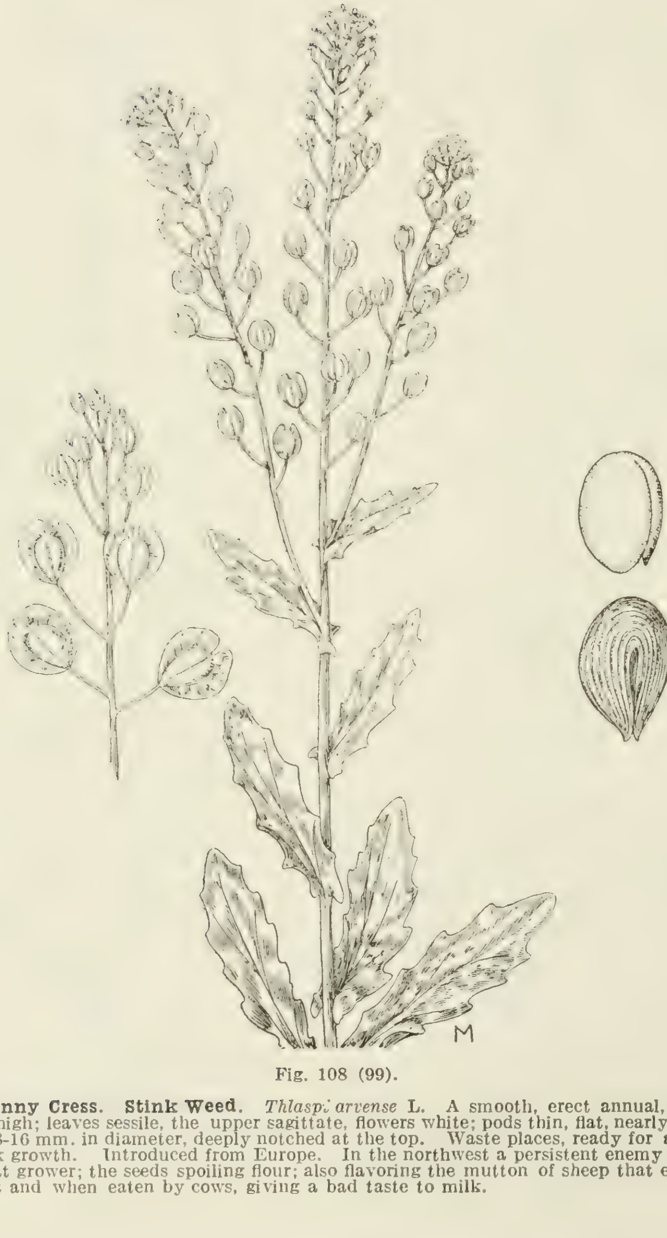


Fig. 108 (99).

Penny Cress. Stink Weed. *Thlaspi arvense* L. A smooth, erect annual, 15-40 cm. high; leaves sessile, the upper sagittate, flowers white; pods thin, flat, nearly circular, 8-16 mm. in diameter, deeply notched at the top. Waste places, ready for a very quick growth. Introduced from Europe. In the northwest a persistent enemy of the wheat grower; the seeds spoiling flour; also flavoring the mutton of sheep that eat the plant and when eaten by cows, giving a bad taste to milk.

ROSE FAMILY. ROSACEAE.

In the most comprehensive sense, this family of moderate size, of 1,500 species, is especially prominent in north temperate region, where it is most remarkable for the extraordinary number of valuable fruits and ornamental plants; it includes apples, pears, quinces, peaches, plums, cherries, almonds, raspberries, strawberries, roses, hawthorns, spiraeas and others; while its weeds are few and insignificant.

Fig. 109 (100).

Mossy Stonecrop. *Sedum acre* L. A smooth, densely tufted, spreading perennial, 3-8 cm. high; leaves sessile, yellowish green, entire, succulent, 3-5 mm. long; flowers yellow. A pretty little plant, escaped from cultivation, especially abundant in sandy land of cemeteries. Introduced from Europe.

ORPINE FAMILY. CRASSULACEAE.

A small family of about 500 species, widely distributed, mostly succulent herbs familiar in species of Live-for-ever and houseleek.

Fig. 110 (101).

Tall Hairy Agrimony. *Agrimonia gyrposepala* Wall. (*A. Eupatoria* in part, not L., *A. hirsuta* Bicknell.) A rough, hairy perennial, 70-120 cm. high; leaves large, thin, leaflets mostly 7, coarsely serrate, interposing segments mostly 3 pairs; flowers yellow; fruiting calyx nearly 1 cm. long; hooks long, widely spreading. Native to this country. Frequent in thin woods where the fruit damages wool.

Fig. 111.

Soft Agrimony. *Agrimonia mollis* (T. & G.) Britton. Grayish-pubescent, root tuberous, 40-180 cm. high; larger leaflets 5-9, oblong, thickish, dull green, crenate to dentate, interposed leaflets mostly one pair; flowers yellow, fruit 4-5 mm. wide, slender bristles chiefly in a single row. Dry woods, troublesome to sheep and cattle. Native to this country.

Fig. 112 (102).

Small-flowered Agrimony. *Agrimonia parviflora* Ait. A hirsute perennial, 70-120 cm. high; leaflets 9-17, crowded, lanceolate or narrower, rather thin, serrate, very glandular with many interposed leaflets of 2-3 different sizes; flowers numerous, 5-6 mm. in diameter, fruit small, loosely reflexed. Sandy shady places. Troublesome to sheep and cattle. Native to this country.

Fig. 113 (104).

Five-finger. A Cinquefoil. *Potentilla Canadensis simplex* (Michx.) T. & G. A herbaceous, slender, tufted, hirsute, perennial, spreading by numerous runners; leaflets 5, oblanceolate, serrate, apex obtuse, flowers single, yellow, achenes smooth.

Dry, sandy or thin soil. Native of this country.

Fig. 114 (103).

Silvery Cinquefoil. *Potentilla argentea* L. Stems ascending, tufted, white-woolly, 10-40 cm. long; leaflets 5, oblanceolate, green above, white pubescent beneath; flowers rather large yellow. Dry, sandy, places introduced from Europe and perhaps native.

Fig. 115 (105).

Rough Cinquefoil. *Potentilla Monspeliensis* L. (*P. Norvegica* L.) An erect, stout, hirsute annual or biennial, 20-90 cm. high; leaves three-foliolate; leaflets obovate to oblanceolate; flowers yellow, usually rather densely cymose, calyx large. Open soil, dry or moist. Native, also found in Europe.

PULSE FAMILY. LEGUMINOSAE.

In the most comprehensive sense this immense family, second in size among seed-plants, includes fully 7,300 species, ranking in size next to the Compositae. The family is the most remarkable of any for the great number and variety of its economic plants. So far as known but few plants outside of this family possess roots which furnish abodes for microbes through whose operation free nitrogen becomes available as plant food. These abodes are familiar objects on roots and are known as tubercles or nodules. Plants of greatest value are the clovers, the alfalfas, beans, peas, lentils, lupines, vetches, cow peas, soy beans. In Leguminosae are found plants of great importance for furnishing medicines, timbers, dye stuffs, gums, for beauty of flowers and foliage. It furnishes a very small number of weeds.

Fig. 116.

Tick-trefoil. *Desmodium canadense* (L.) DC. Perennial, stem hairy, 50-150 cm. high, leaflets oblong-lanceolate, obtuse, much longer than the petiole; flowers pink, showy, 8-12 mm. long. Open woods; common in September, when the fruit is maturing especially annoying to sheep and cattle. A dozen or more species of "tick-trefoil" are denizens of open woods, all bearing burs annoying to sheep and cattle.

Fig. 117. (107.)

Bird's-foot Trefoil. Bloom-fell. *Lotus corniculatus* L. Perennial from a long root, stems slender, prostrate or ascending 5-60 cm. long; leaves hairy, leaflets three, each oblanceolate or obovate, stipules much resembling the leaflets; corolla yellow; pod linear, 2-3 cm. long, several seeded. Introduced from Europe and may soon be expected in Michigan.

Fig. 118 (109).

Alfalfa. Lucerne. *Medicago sativa* L. Perennial from a deep stout root; stem 30-40 cm. high, nearly smooth, leaflets three, dentate, varying much in width; flowers bluish purple, rarely yellow or white; pod pubescent twisted into two or three spirals. Placed here not as a weed but for comparison.

Fig. 119 (108).

Black Medick. Nonesuch. *Medicago lupulina* L. Annual, minutely pubescent mostly prostrate, spreading, 30-60 cm. long; leaflets three, obovate or circular, variously toothed; flowers yellow, fruit in heads, pod curved into a spiral, one-seeded. Introduced from Europe and often found in Michigan. The seeds are not unfrequently used to adulterate those of Alfalfa.

Fig. 120 (110).

White Sweet Clover. *Melilotus alba* Desv. Usually biennial, erect, smooth 90-300 cm. high; leaflets three, serrate, varying much in width, 10-20 mm. long, not twisted.

Somewhat extensively sown as a bee plant along highways of the state. Considerably resembling alfalfa, but may be distinguished by smelling of the crumpled leaves, those of Melilotus resembling the odor of the tonka bean. Offensive to cattle, which may be educated to eat it. Valuable to plow under for enriching the land. Seeds used to adulterate those of Alfalfa. Introduced from Europe.

Fig. 121.

Yellow Sweet Clover. *Melilotus officinalis* (L.) Lam. Resembles the former; flowers yellow; thriving on moist clay soil, not much of a weed in Michigan.

Fig. 122.

Rabbit-foot Clover. *Trifolium arvense* L. A slender, erect, silky, hairy annual, 15-25 cm. high; leaflets three, sessile, narrowed at the base; calyx silky; corolla whitish. Not common nor troublesome. Sandy, barren soil. Introduced from Europe.
If eaten by horses, the flower heads collect intc balls, closing the intestines.

Fig. 123 (111).

Alsike Clover. *Trifolium hybridum* L. Biennial, perennial (?), smooth, stems weak, 30-60 cm. long; leaves with long petioles, leaflets three; obovate, narrowed at the base, serrulate; heads of flowers without an involucre, peduncle long, corolla pinkish white. Never a weed but placed here for the purpose of comparison.

Fig. 124 (112).

Crimson Clover. Scarlet Clover. Italian Clover. *Trifolium incarnatum* L. Annual, erect, soft, pubescent, 15-90 cm. high; leaves long petioled, leaflets nearly sessile, obovate, narrowed at the base, denticulate; heads terminal becoming spikes, 2-5 cm. long; flowers sessile, calyx hairy, corolla crimson, very showy.

Dangerous to feed horses, as the hairy calyces form balls in the stomach and clog the intestines Not a weed but included here for comparison. Introduced from Europe.

Fig. 125 (113).

Red Clover. *Trifolium pratense* L. A well-known useful plant, drawings inserted here for comparison. Introduced from Europe.

Mammoth Clover. A race obtained by selection from red clover from which it gradually merges with all intermediate grades. The seeds of this and red clover are indistinguishable.

Fig. 126 (114).

Low Hop Clover. *Trifolium procumbens* L. A low, bushy annual, 10-20 cm. high; leaflets obovate, wedge-shaped, finely toothed, the terminal one distinctly stalked; heads globose; flowers yellow, at length reflexed, corolla striate, becoming brown when dry. Large plants sometimes become tumble-weeds. Introduced from Europe.

Fig. 127.

Yellow Clover. Hop Clover. *Trifolium agrarium* L. Scarcely a weed, much resembles the preceding; the three leaflets of this are all sessile while the center one of the preceding is raised on a very short stem.

Fig. 128 (115).

White Clover. Dutch Clover. *Trifolium repens* L. A perennial, creeping by the reclined branches which root at the joints, 10-30 cm. long; leaves with long stems, leaflets three, all from the same point, obovate, toothed; heads globose, on long stems; flowers white, the stems finally reflexed when the seeds mature. Scarcely a weed; noticed here for convenience of comparisons. Introduced from Europe.

WOOD SORREL FAMILY. OXALIDACEAE.

A small family containing about 270 species, with clover-like leaves, sour to the taste.

Fig. 129.

Yellow Wood Sorrel. *Oxalis corniculata* L. (*Oxalis cymosa.*) Annual or perennial, pale green herbs, spreading, 15-30 cm. high; leaflets three, closing when touched or at night; flowers yellow; capsule five-sided, 15-22 mm. long. Woods and fields, native to this country.

GERANIUM FAMILY. GERANIACEAE.

A small family of herbs or slightly woody plants of 450 species, most abundant in South Africa, where thrive many of the species now in cultivation.

Fig. 130 (116).

Storks bill. Alfilaria. *Erodium cicutarium* (L.) L'Her. A spreading, hairy annual, 15-30 cm. high; leaves pinnate, the leaflets more or less lobed; petals purple or pink. Introduced from Europe.

Fig. 131 (117).

Cut-leaved Crane's Bill. *Geranium dissectum* L. A slender, spreading annual, 10-30 cm. high; leaves deeply cleft into narrow segments; petals purple; lobes of capsule and beak pubescent, seeds shot from the parent plant.

Introduced from Europe; still scarce in Michigan.

Fig. 132 (118).

Small-flowered Crane's Bill. *Geranium pusillum* Burm. f. A weak, slender, spreading, pubescent annual, 10-40 cm. high; leaves circular in outline, deeply divided into 7-9 lobes; corolla pale purple, petals minutely notched; lobes of capsule hairy, not wrinkled. Seeds well scattered by the parent plant. Introduced from Europe. A "nasty" little thing.

SPURGE FAMILY. EUPHORBIACEAE.

Plants usually pervaded by an acrid, milky juice; flowers too difficult to understand by any one not well trained; 4,000 species with wide distribution. Croton, Poinsettia, Ricinus are ornamental; a few are weeds.

Fig. 133 (119).

Three-Seeded Mercury. *Acalypha Virginica* L. An erect, dark green or purplish annual, 20-60 cm. tall; leaves mostly ovate, coarsely serrate; flowers monoecious, inconspicuous; the plant has a weedy aspect.

A native widely distributed in open places.

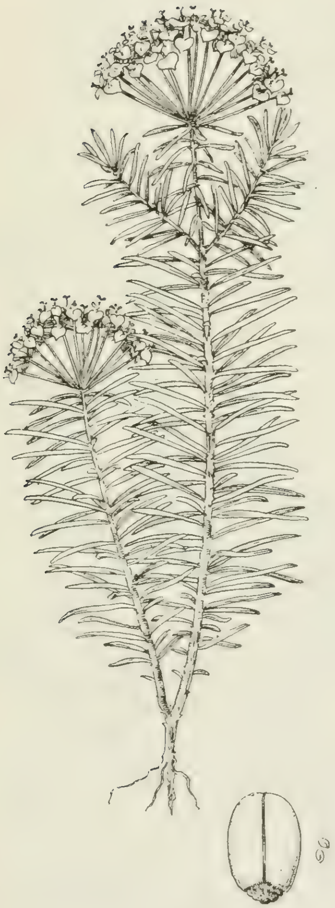


Fig. 134 (120).

Cypress Spurge. *Euphorbia Cyparissias* L. A densely clustered perennial, 10-30 cm. high, milky juice profuse; leaves abundant, very narrow, 2-3 cm. long; flowers and bracts in yellowish clusters, conspicuous. Escaped from cultivation, especially abundant in sandy cemeteries. Introduced from Europe.

Fig 135. (121).

Toothed Spurge. *Euphorbia dentata* Michx. An erect, dull green, pubescent annual, 25-100 cm. high; leaves petioled, ovate, coarsely toothed, 4-8 cm. long, the upper often paler at the base.

A native thriving in rich soil, oftener south of Michigan.

Fig. 136 (122).

Leafy Spurge. *Euphorbia Esula* L. A smooth, erect, perennial, 30-120 cm. high, spreading by rootstocks; leaves numerous, lanceolate; flowers clustered in umbels. Waste places, introduced from Europe.

Fig. 137 (123).

Euphorbia hirsuta (Torr). Wiegand. A spreading, hairy annual, branching at the base, 20-30 cm. high; leaves 8-14 mm. long, oblong. Widely scattered.

Fig. 138 (124.)

Spotted Spurge. *Euphorbia maculata* L. A prostrate, pubescent, dark green annual, 3-15 cm. long, often dark red; leaves usually blotched, oblong, obtuse, very unequal, lobed at the base. Not starting till the weather becomes warm. A native very widely distributed.

Fig. 139 (125).

Upright Spotted Spurge. *Euphorbia Preslii* Guss. (*Euphorbia nutans* Lag.) Annual, mostly smoooth, ascending, spreading, recurved, 15-60 cm. long; leaves oblong, or narrower, often curved to one side, serrate, usually with a red blotch and red margins, lobes unequal.

Native at the east, introduced into Michigan mixed with seeds of red clover.

Fig. 140.

Seaside Spurge. *Euphorbia polygonifolia* L. A slender, smooth, pale green, prostrate annual, 7-10 cm. long; leaves linear, fleshy, obtuse, sandy shores of the Atlantic, and the Great Lakes, and more or less inland.

Spurge *Euphorbia.* Half a dozen other species have been found in the state, some of which may become troublesome at any time.

Fig. 141 (126).

Thyme-leaved Spurge. *Euphorbia serpyllifolia* Pers. A smooth, slender, prostrate, spreading annual, dark green or becoming red, 10-30 cm. long; leaves oblong, sharply serrulate, 6-12 mm. long often with a red spot.

A native widely scattered, thriving on sandy soil.

SUMACH FAMILY. CASHEW FAMILY. ANACARDIACEAE.

Trees or shrubs pervaded by resinous or milky, acrid juice; fruit mostly in the form of a drupe. Some of the sumachs are occasionally annoying owing to the fact that the plants spread rapidly by long sprouting roots, but the chief reason for notice here is the fact that some of them are very poisonous to the touch to some persons; about 400 species mostly confined to warm regions.

Fig. 142 (127).

Poison Ivy. *Rhus Toxicodendron* L. A bushy vine climbing by rootlets over walls and up the trunks of trees; leaves compound, consisting of three leaflets, well shown in the illustration. Very poisonous to the touch to many persons. A rather attractive plant. Native to this country.

Fig. 143.

Poison Elder. Poison Sumach. [*Rhus Vernix* L. A shrub or small tree, 2-5 m. high; leaflets 7-15, obovate-oblong, entire. Thriving in swamps where the leaves assume very attractive tints in autumn. To many persons very poisonous to the touch. Native to this country.

MALLOW FAMILY. MALVACEAE.

Herbs or shrubs, pervaded by an innocent mucilaginous sap. Some species are ornamental, such as Abutilon, Althaea, Hibiscus; a few are weeds. Indian Mallow affords tough bark for cordage.
A small family widely distributed in tropical and temperate regions.

Fig. 144 (128).

Velvet Leaf American Jute. *Abutilon Theophrasti* Medic. (*Abutilon Avicennae* Gaertn. *Abutilon Abutilon* Rusby.) A finely velvety annual, 60-120 cm. high; leaves roundish, heart-shaped, velvety; corolla yellow; heads of fruit, 2-2.5 cm. broad; pistils 12-15, beaked, opening with age. Naturalized from Southern Asia, occasionally found in the southern peninsula. The plant likes warm weather and deep rich soil.

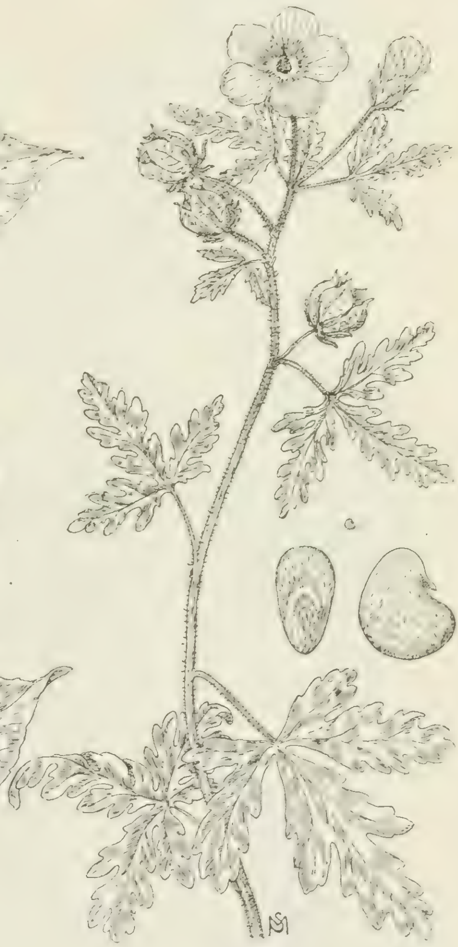


Fig. 145 (129).

Bladder Ketmia. *Hibiscus Trionum* L. A low rather hairy annual; upper leaves three-parted; flowers pale yellow with a purple eye; calyx in fruit inflated, five-winged.

Fig. 146 (130).

Common Mallow. Cheeses. *Malva rotundifolia* L. A procumbent biennial or perennial, with a deep tap root; stems 10-30 cm. long; leaves round, heart-shaped, petioles very long; corolla white or pale blue; pistils crowded into a circle about 15 in number. Introduced from Europe; becoming common.

Fig. 147 (131).

Whorled Mallow. *Malva verticillata* L. An erect annual, 1-2 m. high, leaf-blades nearly circular; flowers small white, crowded. Introduced from Europe to the West and from the West to Michigan.

Fig. 148.

Small-flowered Mallow. *Malva parviflora* L. One introduced from the West and grown for two years at the Agricultutal College, perhaps now exterminated. It may come again at any time with seeds of clover or alfalfa.

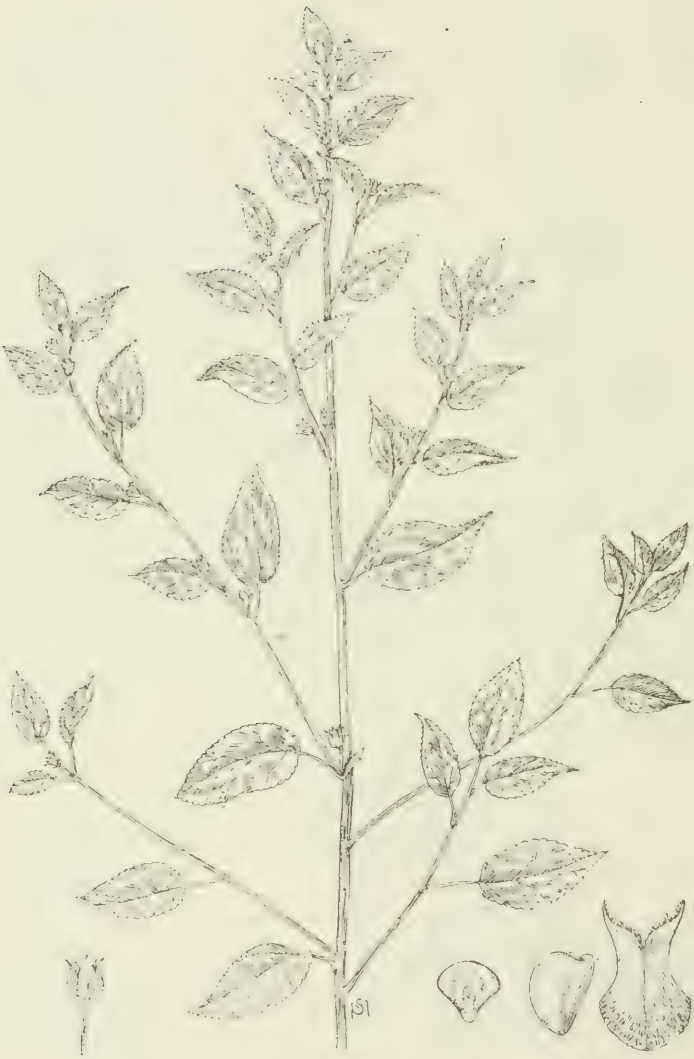


Fig. 149 (132).

Prickly Sida. *Sida spinosa* L. An erect, softly pubescent annual, 30-60 cm. high; leaves mostly ovate, serrate with long stems; flowers small yellow; pistils five-jointed together forming an egg-shaped fruit; each splitting at the top into two beaks. Apparently a native in some portion of the United States. Thriving well southward.

ST. JOHN'S-WORT FAMILY. HYPERICACEAE.

Herbs or shrubs, leaves with pellucid dots, punctate or black. A small family consisting of about 280 species, native of temperate and warm regions.

Fig. 150. (133).

Common St. John's-wort. *Hypericum perforatum* L. A herbaceous perennial. 30-60 cm. high, spreading by runners at the base; leaves sessile, elliptical with pellucid dots; petals deep yellow, black-dotted along the margins, twice as long as the sepals; stamens numerous; pistil three-celled. Rather bad in old meadows and roadsides. Introduced from Europe. Of eighteen or more native species none are weeds.

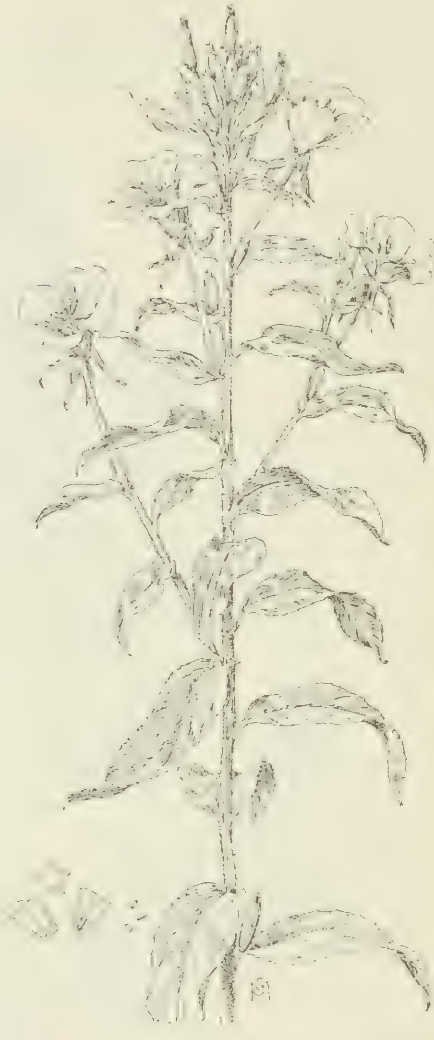
VIOLET FAMILY. VIOLACEAE.

Herbs or shrubs, of which most violets are usually easily recognized; mostly ornamental and harmless. Pansies are in cultivation for their unique flowers.

About 300 species of wide distribution.

Fig. 151.

Wild Pansy. *Viola arvensis* Murr. A slender, erect, biennial, 20-30 cm. high; petals pale yellow; small; capsule, like most violets, when mature splitting into three pieces, each with seeds attached along the middle, the seeds gradually shot in every direction, some of them to a distance of ten feet on level ground. This habit makes it very difficult to keep within bounds when cultivated in a botanic garden, where it becomes quite a pest. Possibly others may find it troublesome.



EVENING PRIMROSE FAMILY. ONAGRACEAE.

This small family of herbaceous plants contains about 350 species of little prominence in an economic way. In Michigan there are a few bee plants and some herbs.

Fig. 152 (135).

Evening-Primrose. *Oenothera. biennis* L. A rather stout, erect, biennial, 30-150 cm. high; leaves narrow, dentate; corolla yellow, opening only in the evening. Open places, common, native of this country.

PARSLEY FAMILY. UMBELLIFERAE.

This rather large family of herbs containing about 1,600 species includes a considerable number that are poisonous when eaten. Here belong parsnips, carrots, dill, caraway, parsley, poison hemlock, sweet cicely, fennel and coriander. Mostly natives of cool regions; species difficult to identify.

Fig. 153 (136).

Beaver Poison. Water Hemlock. Musquash Root. *Cicuta maculata* L. A rather slender, stiff, open-topped perennial, 1-2.2 m. high, having fleshy roots; leaves compound, the segments serrate; flowers white, fruit borne in compound umbels. A native; abundant on low, moist land. Very poisonous.

Fig. 154 (137).

Poison Hemlock. Spotted Cowbane. *Conium maculatum* L. An erect, much-branched biennial, stems spotted, 60-150 cm. high; leaves well dissected; flowers white; umbels compound. For details consult some manual of botany. Criminals and philosophers were not unfrequently put to death at ancient Athens by this plant. Introduced from Europe.

Fig. 155 (138).

Wild Carrot. *Daucus Carota* L. An erect, rough, bushy biennial, 30-90 cm. high; root more or less fleshy; leaves variously lobed and dissected; flowers white, umbels compound; each half fruit bearing four vertical rows of stiff bristles to aid in dissemination. These bristles rub off when passing through a clover huller. When ripe, the rays of the umbel curve toward each other reminding one of a bird's nest. One of our very worst weeds, widely disseminated and rapidly spreading in old pastures and roadsides. Introduced from Europe. Wild carrot is simply the cultivated carrot escaped from cultivation.

Fig. 156 (139).

Wild Parsnip. *Pastinaca sativa* L. A rather stout, smooth, biennial, 60-150 cm. high, stem grooved, leaves pinnate; flowers yellow; umbels compound; fruit flat, broadly oval.

PRIMROSE FAMILY. PRIMULACEAE.

Plants herbaceous, stamens opposite the lobes of the corolla; ovary with one loculus; placenta free central. The family contains primroses, loosestrife, money-wort, pimpernel, American cowslip.

Fig. 157.

Moneywort. *Lysimachia Nummularia* L. A trailing vine with opposite roundish leaves and yellow flowers. A rather pretty plant; escaped from cultivation; introduced from Europe. In some regions a great pest in thin lawns.

DOGBANE FAMILY. APOCYNACEAE.

This family of over 1,000 species mostly found in tropical regions contains herbs, shrubs and trees; ours all herbs, usually abounding in an acrid, milky juice. Botanically nearly allied to the common milk-weeds.

Fig. 158.

Indian Hemp. *Apocynum cannabinum* L. Usually smooth, erect, branching, perennial, 20-240 cm. high, coming from vigorous widely extending rootstalks; bark very tough; flowers small, white; leaves narrow; pods in pairs, terete, about 10 cm. long. A native growing on damp, rich soil, on thin soil smaller and less erect.

Fig. 159.

Apocynum cannabinum hypericifolium (Ait.) A. Gray. Not so tall, leaves broad at the base, abruptly pointed at the apex.

MILKWEED FAMILY. ASCLEPIADACEAE.

Perennial herbs or shrubs, mostly having milky juice; flowers too peculiar for beginners, mostly born in umbels; pod one-celled, bearing flat seeds with silky hairs at one end.

A large family, containing 1,900 species mostly found in tropical or warm temperate regions.

Fig. 160 (140).

Common Milkweed. *Asclepias Syriaca* L. Stem stout, usually unbranched, finely pubescent, coming from deep, fleshy roots difficult of extermination; leaves opposite, broad, flowers in umbels; pods 8-13 cm. long, covered with soft spinous processes.

A native plant very troublesome on sandy land in the northern part of the state where the crop is undisturbed for more than two years. Occasionally "sick" with a pale, dwarf growth, a bacterial disease.

MORNING GLORY FAMILY. CONVOLVULACEAE.

Chiefly twining vines, often containing milky juice; a few cultivated for ornament, and one, the sweet potato, for its edible roots; a number are leafless parasitic vines.

A rather large family including 900 species, mostly native to the tropics.

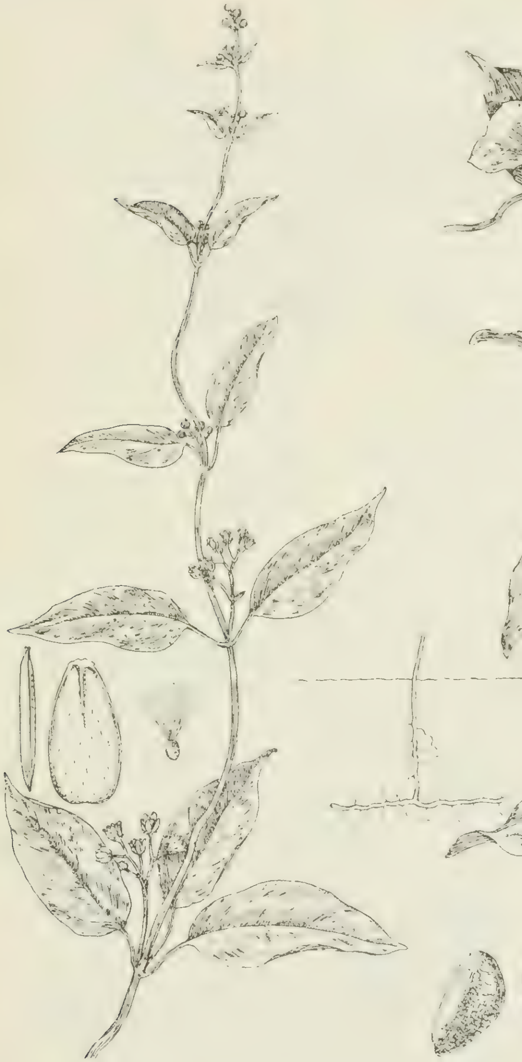


Fig. 161 (141).

Black Swallow-wort. *Cynanchum nigrum* (L.) Pers. (*Vincetoxicum nigrum* Moench.) A rather neat, smooth, dark green perennial twining vine; 60-150 long; leaves narrow; flowers small, dark purple; pods about 5 cm. long.

Introduced from Europe and a pest in land not cultivated.

(Fig. 161 belongs to the Milkweed family.)

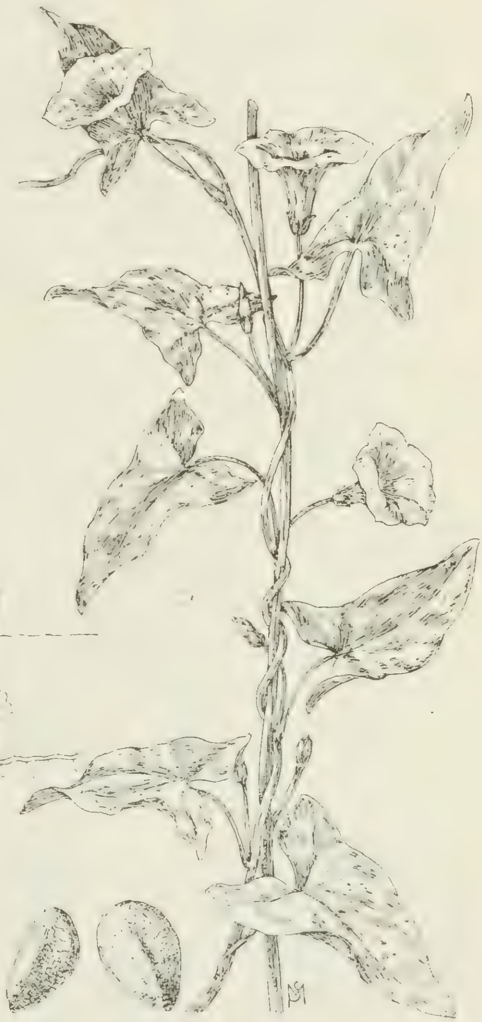


Fig. 162 (142).

Small Bindweed. *Convolvulus arvensis* L. A smooth, slender, prostrate or twining vine from deep, widely spreading, perennial, fleshy roots; leaves arrow or halberd shaped, 2-3 cm. long; flowers bell shaped, seldom abundant, white or tinged with pink, 1.5-2 cm. long.

A very persistent weed when growing in sandy land. Introduced from Europe.

Other names sometimes used; Hedge-bells, Bearbind, Bellbine, Corn-bind, Lap-love, Sheepbine.

Very troublesome in sand or gravel.

Fig. 163 (143).

Hedge Bindweed. Great Bindweed. *Convolvulus sepium* L. A long, trailing or climbing herbaceous vine from a perennial fleshy root, usually smooth; leaves petiolate, blades triangular in outline, halberd-shaped, acute; corolla, bell-shaped, white or tinged with pink, 3-5 cm. long. A native plant seldom producing seeds. Moist soil.

Other names used, Bell-bind, Wood-bind, Lady's Night-cap, Hedge Lily.

Fig. 164. Fig. 165. Fig. 166.

Fig. 164 (144). **Field Dodder.** *Cuscuta arvensis* Beyrich. A pale yellow, slender, leafless, parasitic vine, branching and spreading and more or less exhausting plants of red clover or alfalfa and some other herbs. Flowers small, white, 1.5-2 mm. long.

Fig. 165 (145). **Flax Dodder.** *Cuscuta Epilinum* Weihe. A very slender, pale yellow or red, leafless parasitic vine, branching and spreading and exhausting plants of flax; flowers small, yellowish. Introduced from Europe and troubling flax.

Fig. 166 (146). **Lesser Clover Dodder. Thyme Dodder.** *Cuscuta Epithymum* Murr. An extremely slender, red, leafless, parasitic vine, branching freely and spreading and more or less exhausting plants of red clover, thyme and a few other plants; flowers white or pinkish. Under favorable conditions living near the ground on low plants all winter. Introduced from Europe.

Fig. 167 (147).

Gronovius' Dodder. *Cuscuta Gronovii* Willd. A yellow-orange, leafless, parasitic vine, branching and spreading freely and becoming attached to a great variety of plants, wild balsam, young twigs of willow, nettles, etc.; flowers white. Native to low or moist land.

Fig. 168 (148).

Spanish Dodder. *Cuscuta planiflora* Tenore. A slender, leafless, parasitic vine, branching and spreading over plants of red clover.

Dodder. *Cuscuta.* Other species may be introduced, but their growth and behavior will be much the same as that of the above species

BORAGE FAMILY. BORAGINACEAE.

Chiefly rough hairy herbs; flowers usually blue or white in one-sided cymes, mostly coiled from the apex when young, and straightening as the successive flowers expand. A rather large family of mucilaginous plants, consisting of 1,500 species.

Here belong heliotrope, mertensia, forget-me-not, gromwell, comfrey, borage, and several weeds.

Fig 169 (149).

Hound's Tongue. *Cynoglossum officinale* L. A stout, coarse, erect, biennial, 40-120 cm. high; corolla reddish-purple; nutlets flat, oblique, roughened with short barbed, hooked prickles, making a sharp bur.

Introduced from Europe into waste places and old pastures.

Fig. 170 (150).

Stick-seed. Bur Seed. *Lappula echinata* Gilibert. (*Echinospermum Lappula* Lehmn.) An erect, rough, annual, 30-60 cm. high; corolla blue. Naturalized from Europe.

Fig. 171 (151).

Beggar's Lice. *Lappula Virginiana* (L.) Greene. A pubescent, branching biennial, 60-120 cm. high; lower leaves with petioles, blades, round-ovate; upper leaves ovate-oblong, acuminate at both ends; racemes very slender, fruit ovoid. A native of rich woods.

Fig. 172 (152).

Red Root. Wheat Thief. Corn Gromwell. *Lithospermum arvense* L. A minutely roughened and hoary biennial, stems spreading, 20-70 cm. high; leaves narrow; flowers small, white, sessile. Especially a wheat weed, as it needs to grow the same as winter wheat in the fall, maturing the next summer. The size of the nutlets makes it somewhat difficult to screen from wheat. Introduced from Europe.

VERVAIN FAMILY. VERBENACEAE.

This family of 1,200 species widely distributed in temperate and warm regions is not prominent in Michigan. It includes species of Verbena and Lantana cultivated for ornament and two or three native weeds of little prominence. It is in great contrast with the rose family of the same size, which affords so many prominent fruits and the queen of flowers, the rose.

Fig. 173 (153).

Blue Vervain. *Verbena hastata* L. An erect, roughish perennial, 30-200 cm. high; leaves rather narrow, taper-pointed; spikes of flowers narrow, erect; flowers violet-blue. At home in low mucky ground. A native plant.

Fig. 174.

Hoary Vervain. *Verbena stricta* Vent. An erect, downy perennial, 30-90 cm. high; stem four-sided; leaves sessile, obovate or oblong, serrate; spikes thick; flowers purple.

A weed in the prairie regions of the state; introduced from the west.

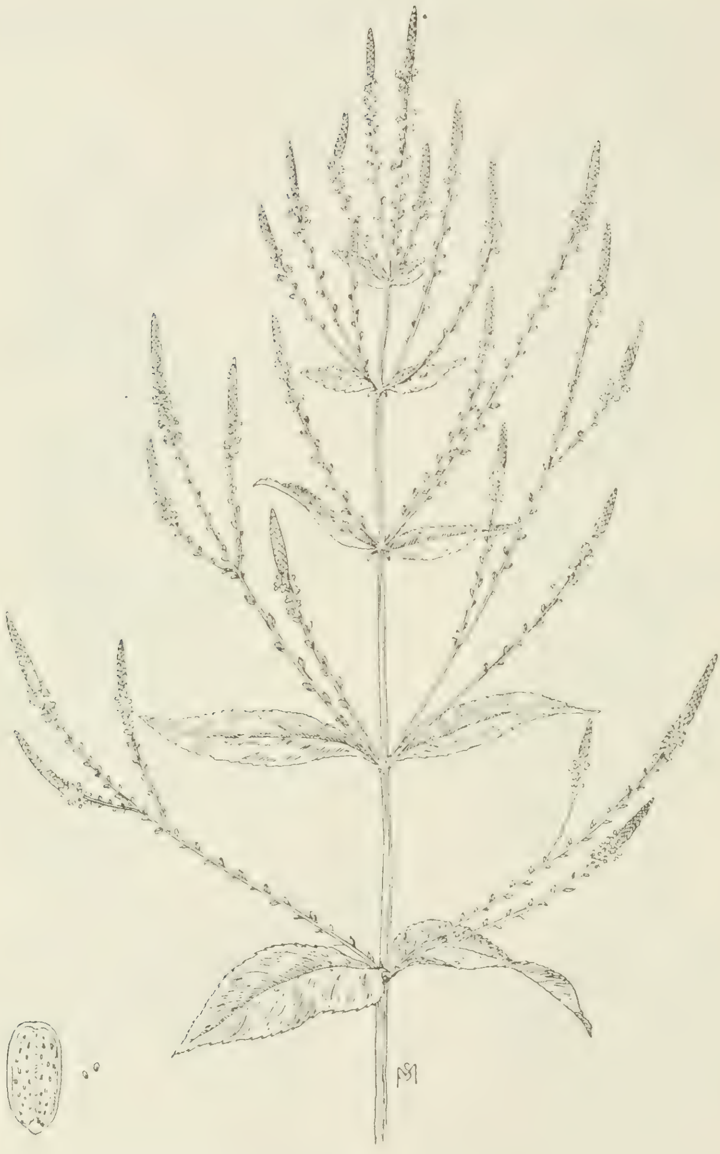


Fig. 175 (154).

Nettle-leaved Vervain. *Verbena urticaefolia* L. Perennial, usually pubescent, stem erect, four-sided; 90-150 cm. high; leaves ovate, or oblong-ovate, coarsely serrate; spikes narrow, interrupted, becoming, 10-15 cm. long; flowers very small, white. Native to low land, hybridizing with *Verbena hastata*, *V. bracteosa*, *V. stricta*.

MINT FAMILY. LABIATAE.

A large family of 3,000 species of aromatic herbs or shrubs, having square stems and opposite leaves; flowers irregular, mostly two-lipped; abounding in temperate and tropical regions. Here belong pennyroyal, germander, skullcap. self-heal, dragon heal, sage, motherwort. horehound, peppermint, catnip, hyssop, marjorum, thyme, stone-root, and many more, often known as sweet herbs. There are some grown for the beauty of their flowers or foliage, a few are weeds. but none are grown in Michigan for fruits, vegetables or forage.

Fig. 176 (155).

Dead Nettle. Henbit. *Lamium amplexicaule* L. Annual or biennial, slightly pubescent; stems slender, weak, spreading, 15-30 cm. high; leaves nearly circular in outline, deeply lobed or toothed; flowers in clusters, corolla, red or purplish.

Introduced from Europe and a bad weed in cool weather, dying in hot weather.

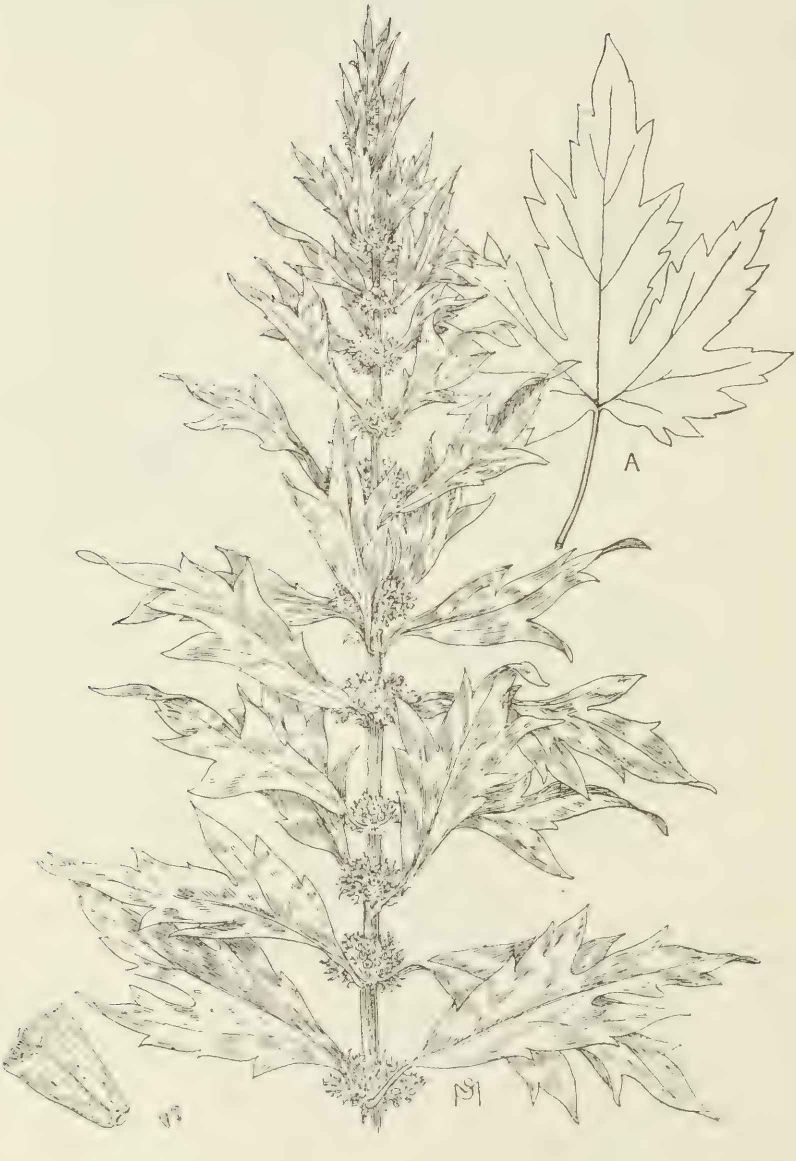


Fig. 177 (156).

Motherwort. *Leonurus Cardiaca* L. A rather stout, erect perennial, 60-120 cm. high; leaves with long stems, the blades broad, 3-5 cleft; corolla pink or purple.
In waste places, introduced from Europe.

Fig. 178 (157).

Hoarhound. *Marrubium vulgare* L. A bitter, whitish-woolly perennial, 30-90 cm. high; leaves veined, circular to oval; densely many-flowered, corolla small, white. Introduced from Europe, and thrives in waste places where plants are protected all winter by snow.

Fig. 179 (158).

Catnip. Catmint. *Nepeta Cataria* L. A downy, erect, pale green perennial, 60-90 cm. high; leaves heart-shaped, oblong, deeply notched; corolla whitish, dotted with purple.
A rather shy weed making little or no trouble. Introduced from Europe.

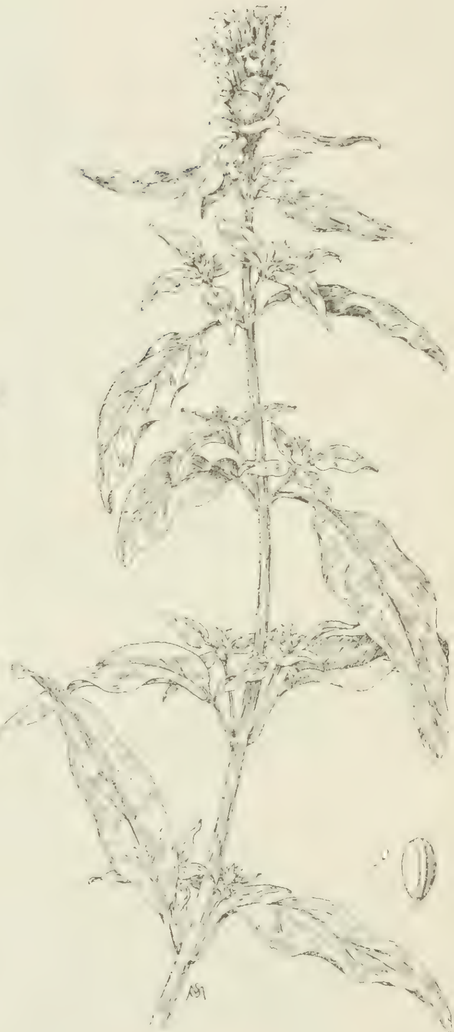


Fig. 180 (159).

Self-heal. Heal-all. Blue-curls. *Prunella vulgaris* L. Hairy or smooth, perennial, often procumbent, 15-40 cm. high; leaves ovate-oblong, entire or toothed; corolla violet, purple or white. Waste places, especially in thin lawns, old meadows and pastures.
Introduced from Europe.

TA O FAMILY. NIGHTSHADE FAMILY. SOLANACEAE.

Herbs or shrubs, foliage rank scented, fruit ranging from very poisonous to edible berries; prominent in the tropics, about 1,600 of them. Here are found the potato, tomato, ground cherry, tobacco, petunia, Jimson weed, henbane, matrimony vine, bittersweet, horse nettle, buffalo bur, apple-of-Peru.

Fig. 181 (160).

Jimson Weed. Thorn Apple. *Datura Stramonium* L. A coarse, narcotic, poisonous, annual, 30-150 cm, high, stems green; corolla white, funnel form, 7-10 cm. high; capsules ovoid, stiff, prickly, about 5 cm. long.
In waste places; introduced from Europe.

Fig. 182 (161).

Purple Jimson Weed. Purple Thorn Apple. *Datura Tatula* L. A coarse, narcotic, poisonous, annual. 30-150 cm. high, stem purple; corolla pale violet-purple, funnel-form, 7-10 cm. high; capsules ovoid, stiff, prickly; very nearly like *D. stramonium* excepting the stems are purple. (The differences being mainly those of color, the same illustration is made to serve for both).
Naturalized from Europe, waste places.

Fig. 183.

Apple-of-Peru. *Nicandra Physalodes* (L.) Pers. (*Physalodes physalodes* (L.) Britton.) An erect, coarse, smooth annual, 60-150 cm. high; stem angled; leaves ovate, toothed, narrowed at the base; calyx enlarged, bladder-like in fruit, enclosing a spherical, dry berry; corolla bell shaped, white with purple spots. Calyx like that of *Physalis*, leaves like those of *Datura*. Waste places, introduced from Peru.

Fig. 184 (163).

Black Nightshade. *Solanum nigrum* L. Usually smooth, branching and spreading, annual, stem rough on the angles, 30-45 cm. high; leaves ovate, wavy-toothed, more or less unequal sided; flowers white; berries spherical, black, appearing as if introduced.

Very extensively distributed as a weed. The berries make good pies; not poisonous when fully ripe.

Fig. 185 (162).

Horse Nettle. Apple of Sodom. *Solanum Carolinense* L. Perennial, rough-pubescent with four-eight-pronged hairs, and stout yellow prickles, erect, 30-120 cm. high coming from numerous deep wandering roots; leaves somewhat resembling those of red oak; berry 1-1.5 cm. broad.

Sandy soil and waste grounds, coming from the southwest.

FIGWORT FAMILY. SCROPHULARIACEAE.

A large family of seed plants consisting of 2,500 species most abundant in temperate regions. Its botanical peculiarities on one side shade off into the potato family and on the other into the mint family.

A remarkably small number of plants are distinguished for economic qualities. A few are ornamental, a few are weeds; there is not a "fruit," "vegetable" or forage plant in the list.

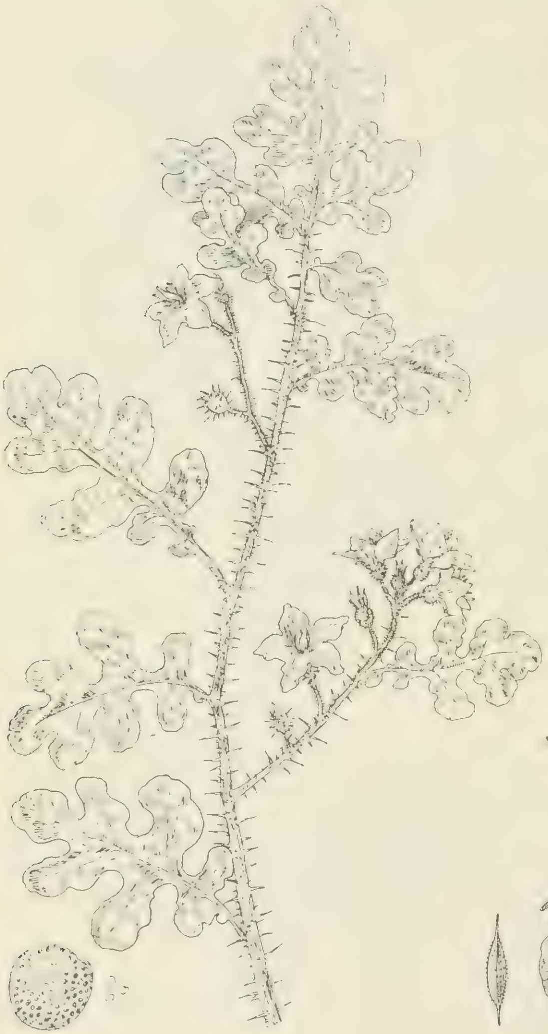


Fig. 186 (164).

Beaked Nightshade. *Solanum rostratum* Dunal. A very prickly, bushy, yellowish, annual, 30-60 cm. high; leaves pinnately-lobed; calyx densely prickly; corolla yellow; fruit a formidable, spiny bur, about 3 cm. in diameter.

Waste places, hailing from the south and west, where it was the original food of the famous potato beetle.

(Fig. 186 belongs to Nightshade family.)

Fig. 187 (165).

Butter and Eggs. Toadflax. *Linaria vulgaris* Hill. (*Linaria Linaria* (L.) Karst.) A pale green, erect perennial, 30-90 cm. high, spreading by slender underground stems; leaves very numerous, very narrow; flowers light yellow and dark orange having a spur at the base.

Naturalized from Europe and widely distributed as a weed in temperate regions.

Fig. 188 (166).

Moth Mullein. *Verbascum Blattaria* L. Biennial, stems slender, erect, branching but little, 60-120 cm. high, smooth or sparingly covered with glandular hairs; leaves rather narrow; raceme loose, simple, long; corolla yellow or white.

A bad weed in old grass land or along road sides. Introduced from Europe.

Fig. 189 (166).

Common Mullein. Velvet-leaved Mullein. *Verbascum Thapsus* L. Biennial, densely woolly throughout, stem simple, erect stout, 30-200 cm. high; leaves oblong, extending down the stem (decurrent); flowers yellow in a very long dense spike.

Introduced from Europe and widely dispersed especially on land recently cleared and in old pastures.

Fig. 190 (167).

Corn Speedwell. Wall Speedwell. *Veronica arvensis* L. Annual, pubescent, simple or branched, 5-40 cm. high; lower leaves petioled, oval, the upper sessile narrow, entire; corolla blue or nearly white.

Cultivated grounds, in old thin grass land. Naturalized from Europe.

Fig. 191 (168).

Common Speedwell. *Veronica officinalis* L. A prostrate, pubescent perennial, spreading by stems rooting at the joints, 7-25 cm. high; leaves oblong, petioled, serrate; racemes narrow, densely flowered; corolla pale blue.

Dry fields and woods, probably a native plant.

Fig. 192 (169).

Neckweed. Purselane Speedwell. *Veronica peregrina* L. Annual, erect, smooth or slightly glandular, 10-30 cm. high; lowest leaves petioled, blades oblong, thickish, the upper leaves sessile, white. Common as a weed in cultivated ground.

Apparently introduced from Europe.

Fig. 193 (170).

Thyme-leaved Speedwell. *Veronica serpyllifolia* L. Perennial, nearly smooth, creeping, much branched, 5-20 cm. high; leaves all opposite and petioled, ovate; raceme loose, corolla whitish or pale blue with deeper stripes. Native and introduced.

PLANTAIN FAMILY. PLANTAGINACEAE.

A small family of herbarious plants, consisting of 200 species, in our region conspicuous for a number of weeds.

One of the peculiarities of the dry fruit in this; when mature it opens all round with a transverse seam.

Fig. 194 (171).

Sand Plantain. *Plantago arenaria* W. & K. A pubescent and somewhat viscid annual; leaves 60-30 cm. high; narrow, opposite or whorled; pod one-seeded.

Found at Harrisville, introduced with clover seed, originally from Central Europe.

Fig. 195 (172).

Large-bracted Plantain. *Plantago aristata* Michx. A dark green annual, usually hairy, 15-30 cm. high; leaves narrow, entire, often three-ribbed; spikes dense, 4-12 cm. long.

Often introduced from the west with clover seed; so far not usually spreading in Michigan.

Fig. 196 (173).

Rib-grass. Narrow-leaved Plantain. Buckhorn. *Plantago lanceolata* L. Mostly perennial, more or less hairy, 30-50 cm. high; leaves narrow, 3-5 ribbed, oblong-lanceolate, entire.

Naturalized from Europe, one of our very worst weeds, as its seeds cannot be readily separated from seeds of red clover; and it springs up very quickly after the lawn mower, becoming very unsightly.

Fig. 197 (175).

Rugel's Broad-leaved Plantain. *Plantago Rugelii* Decne. Leaves thinner, always crimson at base, spikes thin, 30-60 cm. high. This species has invaded fields of the farm and become a serious pest; often found in seeds of red clover, a native to some portions of our country.

Fig. 198 (174).

Broad-leaved Plantain. *Plantago major* L. Perennial, smooth or hairy, 15-90 cm. high; leaves light green, 3-11-ribbed, base of all leaves without tinge of crimson.

Possibly a native of some region of North America. Not a vigorous weed in Michigan.

MADDER FAMILY. RUBIACEAE.

An immense family of 5,500 species of wide geographical distribution, abundant in tropical regions. The coffee plant belongs here, Partridge Berry, Bed Straw, Button Bush. One weed is noticed. Here are a few of the common names applied to species of *Galium*: Cleavers, Goose-grass, Bushead, Clover-grass, Cling-rascal.

Fig. 199. **Fig. 200.** Fig. 201.

Fig. 199. *Galium asprellum* Michx.

Fig. 200. *G. circaezans, G. lanceolatum, G. pilosum, G. trifidum, G. boreale.*

Fig. 200a (176). **Blue Field Madder.** *Sherardia arvensis* L. Through an oversight no drawing of 200a was prepared. A slender, tufted, roughish, prostrate plant, 7-25 cm. high; leaves in fours and sixes, narrow; fruit crowned with the 4-6, calyx teeth. Introduced into this country from Europe and spreading with clover seed.

Fig. 201. **Sweethearts.** *Galium Aparine* L. Annual, weak, climbing over plants, by means of stout, recurved prickles on the stems, 60-150 cm. high; leaves in sixes and eights, narrow; in 1-3-flowered clusters; fruit densely covered with sharp hooked bristles. Widely distributed under some 70 common names; probably introduced from Europe.

A considerable number of other species of *Galium*, such as *G. lanceolatum, G. pilosum, G. trifidum, G. boreale*, mostly natives grown in woods become a pest to sheep, if allowed to roam about in late summer and autumn.

TEASEL FAMILY. DIPSACACEAE.

A very small family of coarse herbs consisting of only 140 species. Natives of the old world. Species of scabious are grown for ornament. The fuller's teasel is grown for the purpose of placing the ripened heads with their stiff-hooked prickles in revolving frames to produce nap on cloth.

Fig. 202](177).

Common Teasel. *Dipsacus sylvestris* Huds. A coarse, prickly biennial, 60-180 cm. high leaves sessile, opposite; heads 7-10 cm. long; flowers lilac in color. Waste places from Europe.

THE THISTLE FAMILY. THE ASTER FAMILY. COMPOSITE FAMILY. COMPOSITAE.

This includes the Chicory Family and the Ragweed Family, sometimes considered as distinct from the Compositae. Botanically this family ranks highest of any. In the most comprehensive sense this immense family of seed plants consists of 11,450 species—much the largest of all. The flowers are produced in heads; the anthers are united into a tube which surrounds the style; there is only one seed to a flower.

Here are found large numbers of showy flowers in cultivation, such as asters, dahlias, chrysanthemums and the largest contributions to the weeds of any family. To the vegetable garden the best it can do is to furnish lettuce, endive, chickory, artichokes, sunflowers. It does not furnish a single plant of importance for meadows or pastures possibly excepting yarrow, which takes a low rank for meadow, pasture and lawn.

Fig. 203 (178).

Yarrow. Milfoil. *Achillea Millefolium* L. Stems simple, slightly woolly, perennial from horizontal rootstocks, 30-60 cm. high; leaves many times finely dissected into almost thread like pieces; heads numerous, small, in a flat-topped cluster, ray flowers white or pink. It seems to be native to this country as well as native to Europe.

Fig. 204.

Biennial Wormwood. *Artemisia biennis* Willd. An erect, smooth, biennial, 30-120 cm. high; leaves divided; heads crowded in short spikes, very numerous, about 3 mm. broad. Introduced into moist ground from the west.

Fig. 205 (179).

Ragweed. Hogweed. *Ambrosia artemisiifolia* L. A hairy, much branched, very variable annual, 30-180 cm. high; leaves thin, cut lobed; racemes of the male flowers very numerous, female heads clustered above the base of the leaves.

Fig. 206 (180).

Great Ragweed. King Head. *Ambrosia trifida* L. A rough or nearly smooth, branched annual, 1-6 m. high; leaves deeply 3-5-lobed; racemes of male heads 4-20 cm. long, female heads clustered above the leaves.

Fig. 207 (181).

Corn Camomile. *Anthemis arvensis* L. Usually annual, not strong scented, finely pubescent, much branched, about 30 cm. high; leaves sessile, on or twice cut lobed; heads usually numerous; 3-4 cm. broad; the ray flowers white.

Fig. 208 (182).

May-weed. Dog-fennel. *Anthemis Cotula* L. Annual, ill smelling, much branched, sometimes pubescent, 30-60 cm. high; leaves finely dissected; heads numerous, about 2-5 cm. broad, rays white.

Fig. 209 (183).

Great Burdock. *Arctium Lappa* L. A large, fine-wooly, coarse, biennial, 1-2 m. high; leaves large mostly heart shaped; heads clustered, 3-5 cm. broad, the outside scales hooked at the top making a formidable bur; flowers purple.

So far as the writer has observed, there are no plants of this species in the state, the following species having heretofore passed for this one. Introduced from Europe.

Fig. 210 (183).

Common Burdock. *Arctium minus* Bernh. A large, fine-wooly, coarse, biennial, 1-2 m. high; leaves mostly heart shaped; heads clustered, 1.5-3 cm. broad, bracts hooked at the apex; flowers purple; abundant in certain portions of the state.

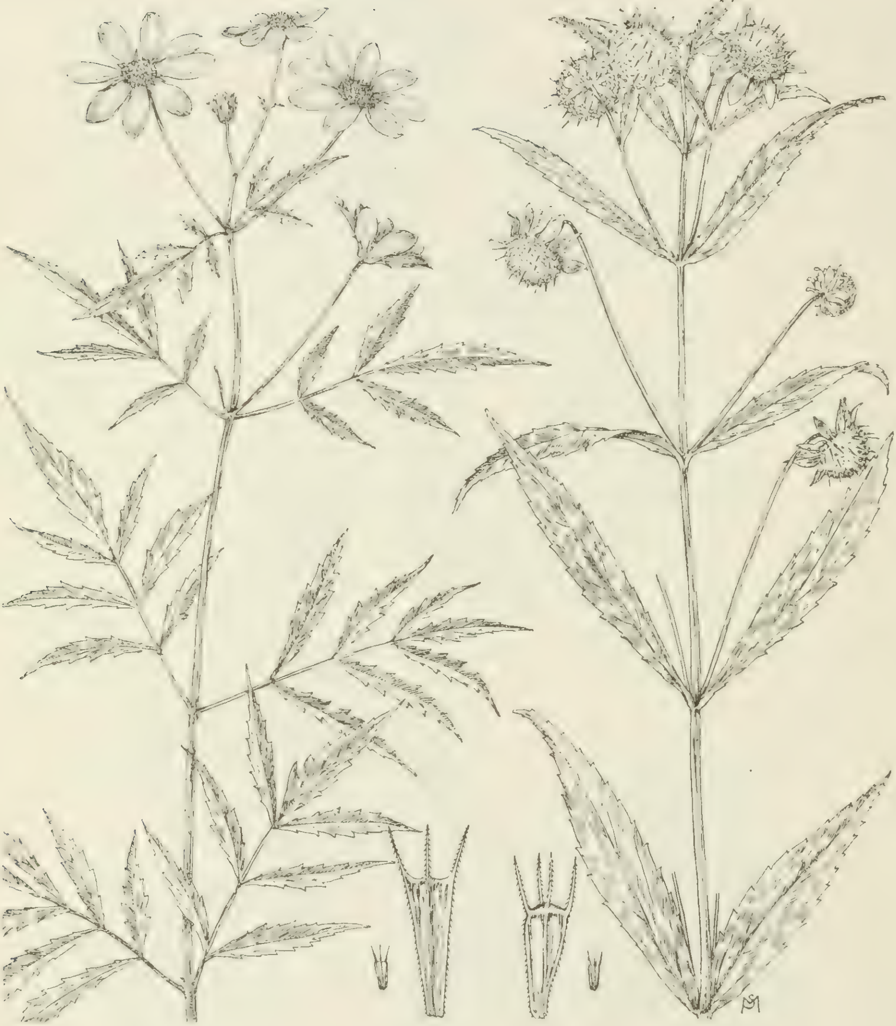


Fig. 211.

Western Tickseed. *Bidens aristosa* (Mich.) Britton. Annual or biennial, much branched, more or less pubescent, 30-90 cm. high; leaves thin, lobes narrow; heads numerous, ray flowers 6-9, showy; achenes flat, upwardly ciliate bearing two parallel teeth.

A native found in swamps and wet land.

Fig. 212 (185).

Stick-tight. Nodding Bur. Marigold. *Bidens cernua* L. Erect, branched, smooth or rough, annual, 20-70 cm. high; leaves narrow, clasping the stem at the base; heads globose, nodding; ray flowers yellow, 6-10 or more.

Fig. 213.

Leafy-bracted Tickseed. *Bidens comosa* (A. Gray) Wiegand. A smooth, straw colored annual, 15-120 cm. high; leaves narrow, not compound; heads few, large; ray flowers wanting; achenes about 1 cm. long, nearly smooth, awns, three-barbed downward.

A native, growing in wet soil.

Fig. 214 (186).

Purple-stemmed Swamp Beggar-ticks. *Bidens connata* Muhl. A smooth, purple, erect, much-branched annual, 15-200 cm. high; leaves narrow; ray flowers none or small.

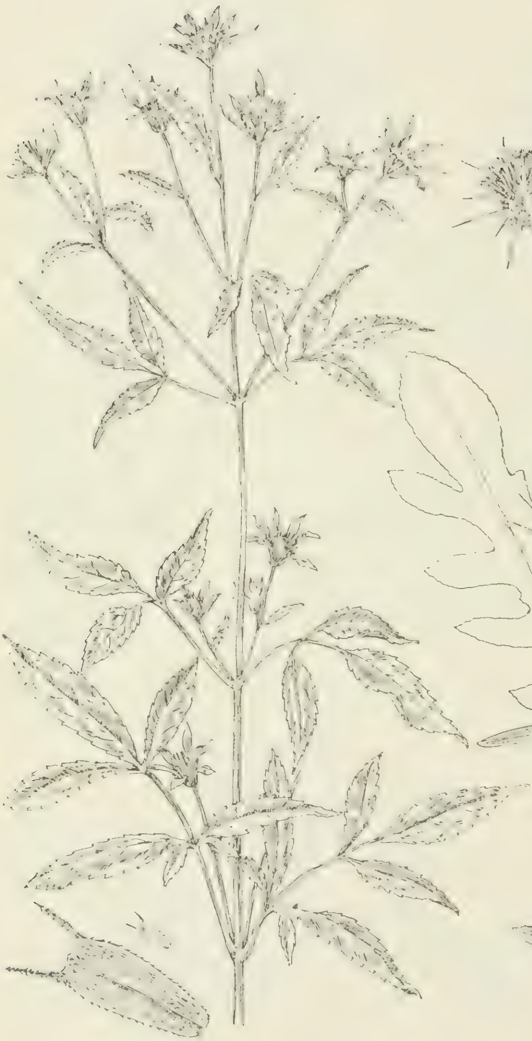


Fig. 215 (187).

Beggar Ticks. Stick-tight. *Bidens frondosa* L. An erect, branched, mostly smooth, annual, 60-250 cm. high; leaves thin, 3-5 divided, the sections narrow; rays none; achenes flat, oval, the two slender awns barbed downward. Damp soil.

Fig. 216 (188).

Star Thistle. *Centaurea solstitialis* L. A straggling plant, gray, with loose woolly hairs, 30-50 cm. high; stem leaves small, narrow, each with one margin growing down the stem; heads about 1.5 cm. broad, some of the stout spiny scales yellow, spreading, 12-18 mm. long.

Fig. 217 (189).

Ox-eye Daisy. *Chrysanthemum Leucanthemum pinnatifidum* Lecoq and Lamotte. Stem erect, branching but little, 30-50 cm. high, perennial from spreading rootstocks; lower leaves mostly spatulate, stem leaves partly clasping; heads 4-6 cm. broad, with 20-30 white rays. Not yet very common in Michigan.

Fig. 218 (190).

Chicory. Blue Sailors. *Cichorium Intybus* L. Whole plant pervaded by milky juice; stem stiff, rough, much branched perennial, 30-90 cm. high, from a long, deep top-root; leaves long, narrow, variable; heads numerous; flowers bright blue.

Waste places, introduced from Europe. Sometimes cultivated for use of the roots as a substitute for coffee or to mix with coffee.

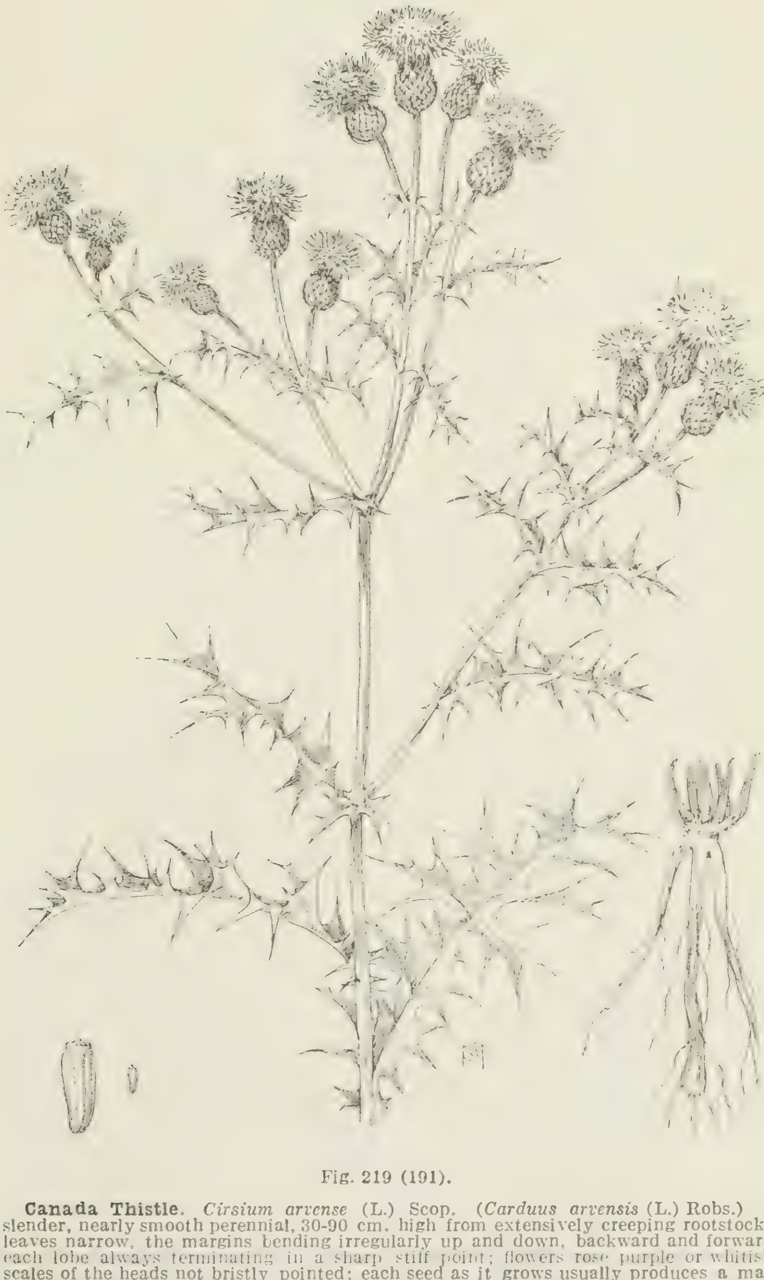


Fig. 219 (191).

Canada Thistle. *Cirsium arvense* (L.) Scop. (*Carduus arvensis* (L.) Robs.) A slender, nearly smooth perennial, 30-90 cm. high from extensively creeping rootstocks; leaves narrow, the margins bending irregularly up and down, backward and forward, each lobe always terminating in a sharp stiff point; flowers rose purple or whitish; scales of the heads not bristly pointed; each seed as it grows usually produces a male plant or a female plant; by rootstocks a half acre or more is often the result of a single seed.

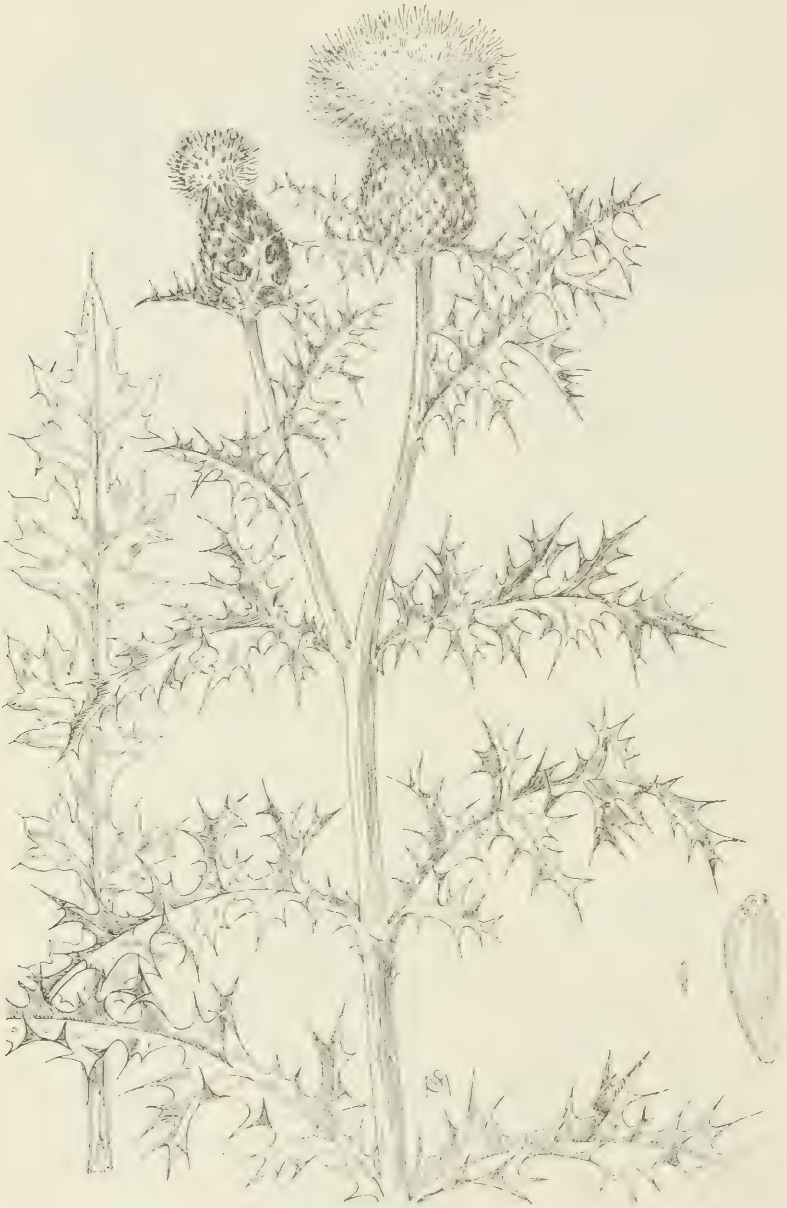


Fig. 220 (192).

Common or Bull Thistle. *Cirsium lanceolatum* (L.) Hill. (*Carduus lanceolatus* L.) A stout, woolly, branched biennial, 90-150 cm. high; leaves variably lobed, extending down the stem (decurrent), everywhere each wavy lobe terminates in a formidable prickle; heads large, mostly solitary, the scales of the involucre each terminating in a bristly prickle.

Fig. 221 (194).

Fire-weed. *Erechtites hieracifolia* (L.) Raf. Annual, mostly smooth, erect, coarse, homely plants with a rank smell, 30-180 cm. high; leaves narrow, variable.
A native plant, springing up in recently burned clearings and where low land has been cultivated. Sometimes harvested in quantities and distilled for the oil.

Fig. 222 (196).

Fig. 223 (196).

Daisy Fleabane *Erigeron annuus* (L.) Pers. A rather slender, erect, leafy biennial, 20-150 cm. high, beset with spreading hairs, lower leaves ovate, mostly obtuse, coarsely toothed, upper narrower, sharply toothed, marginal flowers very numerous, white or tinged with purple. Study well and compare with *Erigeron ramosus*. The achenes are so nearly like those of *E. ramosus* that it did not seem worth while to make drawings of the species.

A native weed; especially abundant in thin grass land.

Daisy Fleabane. *Erigeron ramosus* (Walt.) B. S. P. Slender, erect, biennial, pubescence closely appressed, 60-150 cm. high; stem-leaves narrow, mostly entire, closely resembles *E. annus* with which carefully compare; found together in similar places, though this species likes sandy and gravelly soil. Stem smaller and more simple than the preceding, with smaller heads but longer rays.

Fig. 224 (195).

Horse-weed. Mare's-tail. A Fleabane. *Erigeron canadensis* L. (*Leptilon canadense* (L.) Britton.) Erect, bristly-hairy, 60-270 cm. high; leaves very numerous,, very narrow; heads very numerous, bearing very short rays on the margins. A native plant now of wide distribution at home and abroad. Waste places, common and abundant. Sometimes cut and distilled for the oil.

Fig. 225 (198).

Low Cudweed. *Gnaphalium uliginosum* L. Annual, much branched from the base, covered all over with appressed wool, 5-30 cm. high; leaves narrow, spatulate; heads small in clusters, bracts brownish.

Fig. 226 (197).

Sweet Life Everlasting. *Gnaphalium polycephalum* Michx. (*G. obtusifolium* L.) Erect, annual or winter annual, fragrant, fine, woolly, 30-70 cm. high; leaves narrow, heads small, numerous, the bracts on the outside whitish, thin, paper-like (scarious).

Fig. 227 (199).

Broad-leaved Gum-plant. Tar-weed. *Grindelia squarrosa* (Pursh) Dunal. Perennial or biennial, smooth, erect, 20-60 cm. high; leaves narrow; often spatulate, base more or less clasping; bracts of the involucre strongly spreading, very glutinous, flowers yellow, native in the west, introduced with seeds of clover and grasses.

Fig. 228 (202).

Elecampane. *Inula Helenium* L. A coarse, stout, erect, pubescent perennial, 60-180 cm. high; lower leaves ovate, petioled, 20-45 cm. long, the upper partly clasping; ray flowers yellow, numerous.

Fig. 229.

Jerusalem Artichoke. *Helianthus tuberosus* L. Stem rough, stout, branched, 120-300 cm. high, perennial by numerous tubers; leaves ovate or narrow, three-nerved, sharp pointed; rays 12-20, yellow, occasionally cultivated and spreading as a weed.

Fig. 230 (200).

Devil's Paint-brush. Orange Hawkweed. *Hieracium aurantiacum* L. A slender, thin, hairy, perennial, 20-60 cm. high, usually spreading by runners, juice milky; leaves mostly at the ground, spatulate; flowers orange-red, showy. Introduced from Europe and escaped from cultivation. A terrific weed when once established.

Fig. 231 (201).

Mouse-Ear. Hawkweed. *Hieracium Pilosella* L. An erect, thin-hairy, perennial, 10-30 cm. high, spreading by runners, juice milky; leaves mostly at the ground, oblong or spatulate; flowers yellow.

Introduced from Europe, having much the habit of *H. aurantiacum*.

Fig. 232 (203).

Marsh Elder. *Iva xanthiifolia* Nutt. Annual, coarse rough, light colored with minute down, 60-180 cm. high; leaves mostly opposite, ovate or rhombic, three-ribbed, more or less lobed; heads small, crowded in panicles. Waste places in the Upper Peninsula.

Fig. 233 (204).

Wild or Tall Lettuce. *Lactuca canadensis* L. A smooth, leafy biennial, 1-3 m. or more high, juice milky; leaves more or less lobed or simple, some of them 30 cm. long; heads 1-1.5 cm. long, numerous, in a large open panicle; flowers yellow.

Fig. 234 (205.)

Prickly Lettuce. *Lactuca Scariola* L. Biennial, erect, stiff, leafy, smooth, except near the base, juice milky, 60-200 cm. high; leaves narrow with spinulose margins, base more or less clasping, tending in open places to turn one edge up, the other down, and to point north and south; flowers pale yellow. A troublesome weed introduced from Europe.

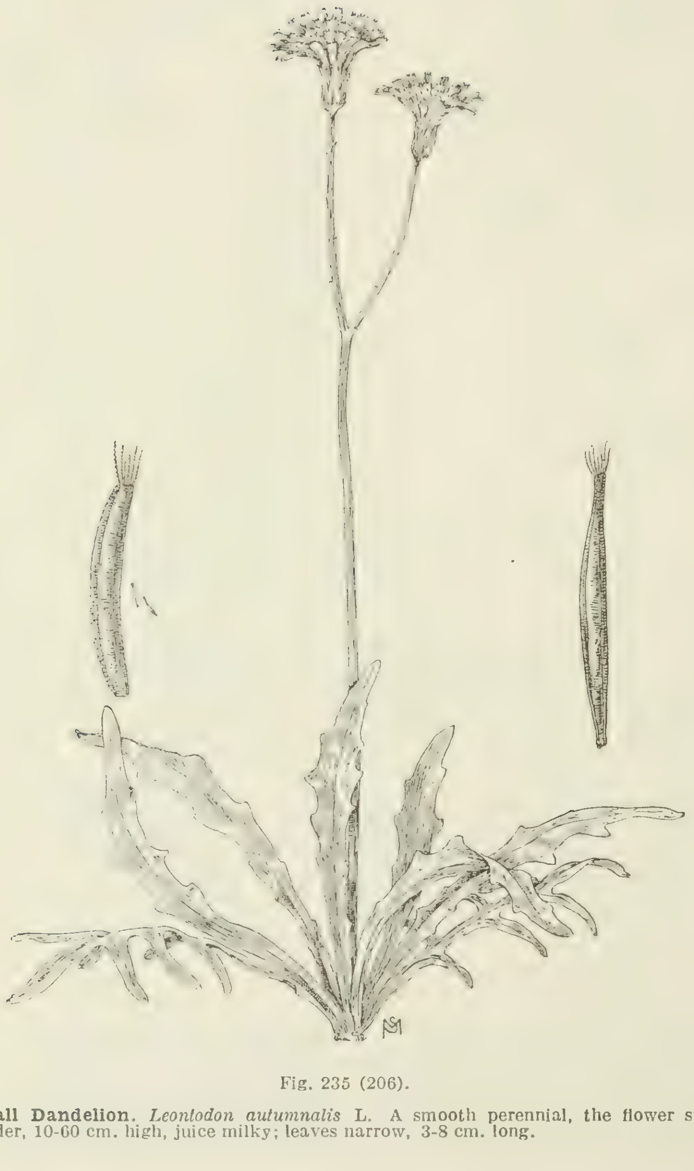


Fig. 235 (206).

Fall Dandelion. *Leontodon autumnalis* L. A smooth perennial, the flower stem slender, 10-60 cm. high, juice milky; leaves narrow, 3-8 cm. long.

Fig. 236 (207).

Black-eyed Susan. Yellow Daisy. *Rudbeckia hirta* L. A very rough, bristly, hairy, erect, biennial, 30-80 cm. high; each stem bearing a single head; leaves narrow, 3-5-nerved; ray flowers orange yellow, often darker at the base, center of the head dark purple, very rarely green. Dry soil, a native in the state; introduced east mixed with clover seeds.

Fig. 237.

Stinking Willie. Staggerwort. *Senecio Jacobaea* L. Perennial, stout, often woolly, very leafy, 60-120 cm. high, having short, thick rootstocks; leaves usually 2-3-times lobed, 2-15 cm. long; heads very numerous in large compact, flat-topped clusters; flowers golden-yellow. Introduced from Europe and found in Maine, Nova Scotia, Quebec, locally in Ontario. Not yet known to occur in Michigan. The plant is very poisonous, causing a fatal disease of the liver in cattle. It is not injurious to sheep.

Fig. 238.

Canada Golden-rod. *Solidago canadensis* L. Stem erect, stout, usually minutely pubescent, 60-150 cm. high; leaves narrow, three-nerved, 6-13 cm. long; heads small, crowded in recurved one-sided racemes. A native plant; very common in low land, where it spreads rapidly by rootstocks. Several other species are just as bad when they are as abundant.

Fig. 239 (208).

Field Sow Thistle. *Sonchus arvensis* L. Chiefly smooth, a coarse weed, juice milky, 60-120 cm. high; spreading by rootstocks; leaves variously lobed, spiny-toothed; flowers yellow. Introduced from Europe and a rampant weed.

Fig. 240 (209).

Spiny-leaved Sow Thistle. *Sonchus asper* (L.) Hill. Chiefly smooth, except margins of leaves, juice milky, 30-90 cm. high; perennial; spreading by rootstocks and seeds; leaves prickly to the touch, not true of the other species; flowers pale yellow. Introduced from Europe.

Fig. 241 (210).

Common Sow Thistle. *Sonchus oleraceus* L. Annual, erect, branching, leafy below; juice milky, 30-180 cm. high; leaves soft-spiny, toothed; flowers pale yellow.

Fig. 242.

Common Dandelion. *Taraxacum officinale* **Weber.** (*Taraxacum Taraxacum* (L.) Karst.) Leaves, very variable, coarsely lobed and toothed; heads large (3-5 cm. broad), orange-yellow. See account of the following species.

Fig. 243 (211).

Red-seeded Dandelion. *Taraxacum erythrospermum* Andrz. Leaves, small, deeply lobed, segments narrow, juice milky; compared with the next species, heads smaller, 2-3 cm. broad, sulphur yellow, the inner bracts, with horn-shaped appendages; achenes smaller; bright red or red-brown, sharply prickled above.

Fig. 244 (213).

Meadow Salsify. Yellow Goat's Beard. *Tragopogon pratensis* L. Very similar to the following species; leaves broader at the base; flowers yellow.

Fig. 245 (213.)

Salsify. Oyster-plant. *Tragopogon porrifolius* L. A stout, smooth, biennial, 45-90 cm. high, juice milky; **leaves long and** very narrow; flowers purple, showy.

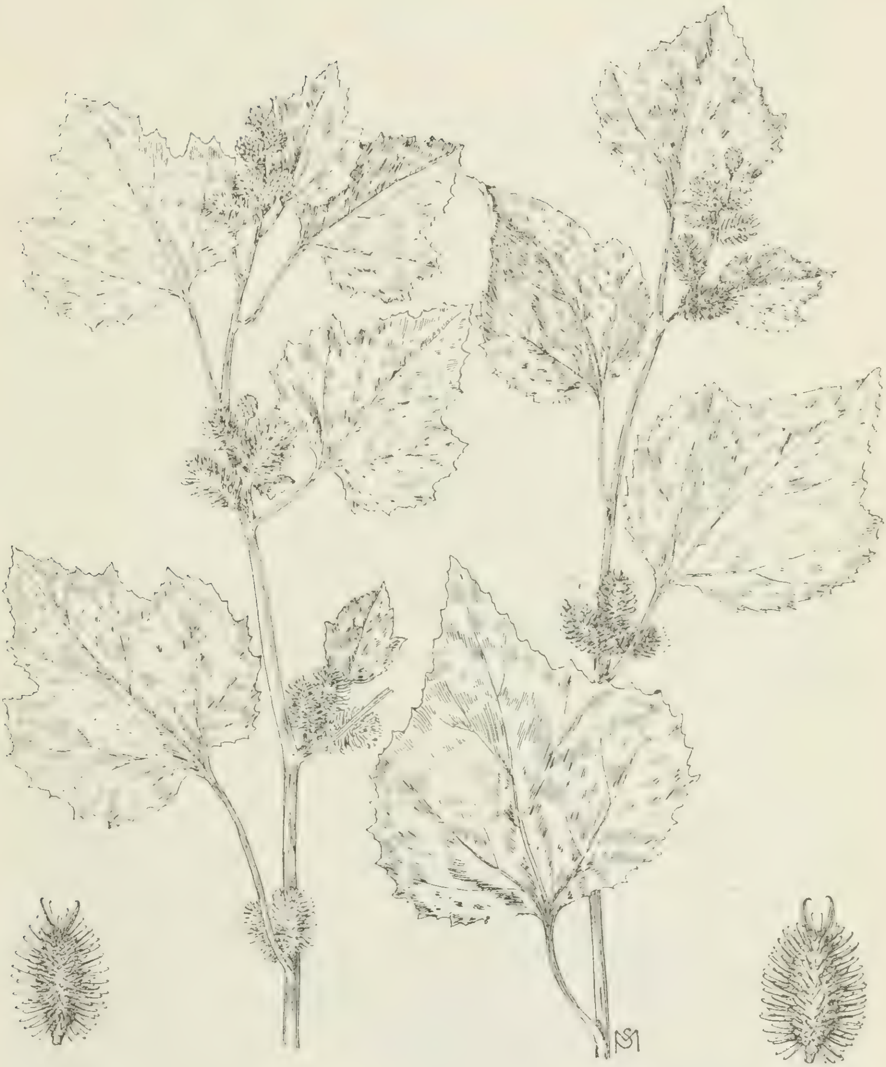


Fig. 246 (214).

American Cocklebur. *Xanthium canadensis* Mill. A coarse, erect annual, 30-120 cm. high; leaves broad, usually three-lobed; burs nearly smooth, 14-17 mm. long, 5-8 mm. in diameter, beaks slightly curved, prickles scattered, slender, hooked.

Fig. 247.

Common Cocklebur. *Xanthium commune* Britton. Much like *H. canadense* beaks of bur incurved, prickles numerous, crowded, 3-6 mm. long, hairy, as is also the body.

Fig. 248 (215).

Spiny Clotbur. *Xanthium spinosum* L. Stems mostly pubescent much branched, 30-90 cm. high; leaves narrow and at the base of each a three-pronged, yellow spine. The drawing is a trifle stiff, and straight for nature.

TUBERCULOSIS IN FOWLS.

Circular No. 12.

Tuberculosis is a very widespread disease. Nearly every species of animal may contract this disease under certain conditions. We are familiar with tuberculosis chiefly as it occurs in human beings, cattle, swine, and chickens, and its economic importance depends largely upon its occurrence in these animals. It is with this disease in poultry that we wish to deal here. A knowledge of the disease is of importance to both consumers and producers, and especially to the latter since they are both producers and consumers.

Tuberculosis in fowls is said to be a serious pest in Europe, but authentic reports of it in this country are not sufficient to warrant us in stating that it is prevalent. As a matter of fact, we do not know how widespread the disease is. We know that it exists to a considerable extent in Ontario, Canada, in Oregon and California, and that it has been found in New York. It has been found in flocks in several counties of Michigan, and occasionally in market chickens.

A single illustration will help to emphasize the importance of this disease: In January, 1911, a large flock of mixed Black Minorcas and Brown Leghorns was found in Livingston county, badly affected with tuberculosis. In the spring of 1910 this flock consisted of nearly 300 birds. By January, 1911, there were about 160 left. A positive diagnosis was made as a result of the examination of a bird sent to this laboratory. An arrangement was made whereby 140 birds were killed and dressed, and the remainder (those visibly affected) were sent to the laboratory for experimental work. Of the 140 birds killed, 40 were found to be tuberculous.

Tuberculosis is found in a great variety of species of birds. It is reported in the common fowl, pea fowl, ducks, turkey, goose, pigeon, dove, grouse, partridge, pheasant, stork, crane, canary, finch, owl, swan, vulture, ostrich and parrot. There are several types of the microörganism causing tuberculosis and we do not know whether the avian type is responsible for the disease in all these species. The relation of tuberculosis in birds to that in mammals is still an unsettled question. It is known that some birds, such as parrots and canaries, die of tuberculosis of human origin. The avian germ is not easily made to reproduce the disease in mammals, but experiments have resulted in its successful transplantation into rabbits, guinea pigs, and a cat as well as pigs. Rats and mice are said to die of avian tuberculosis in bird parks of zoological gardens, and in turn infect birds that feed upon their dead bodies. It is not easy to produce tuberculosis in chickens by feeding human tuberculous sputum, but there is a record of a whole flock of chickens infected by the sputum of a tuberculous man who used to sit in the yard

surrounded by the chickens that greedily devoured his sputum. Tuberculosis was found in cattle on the same ranches in California that reported the disease in chickens.

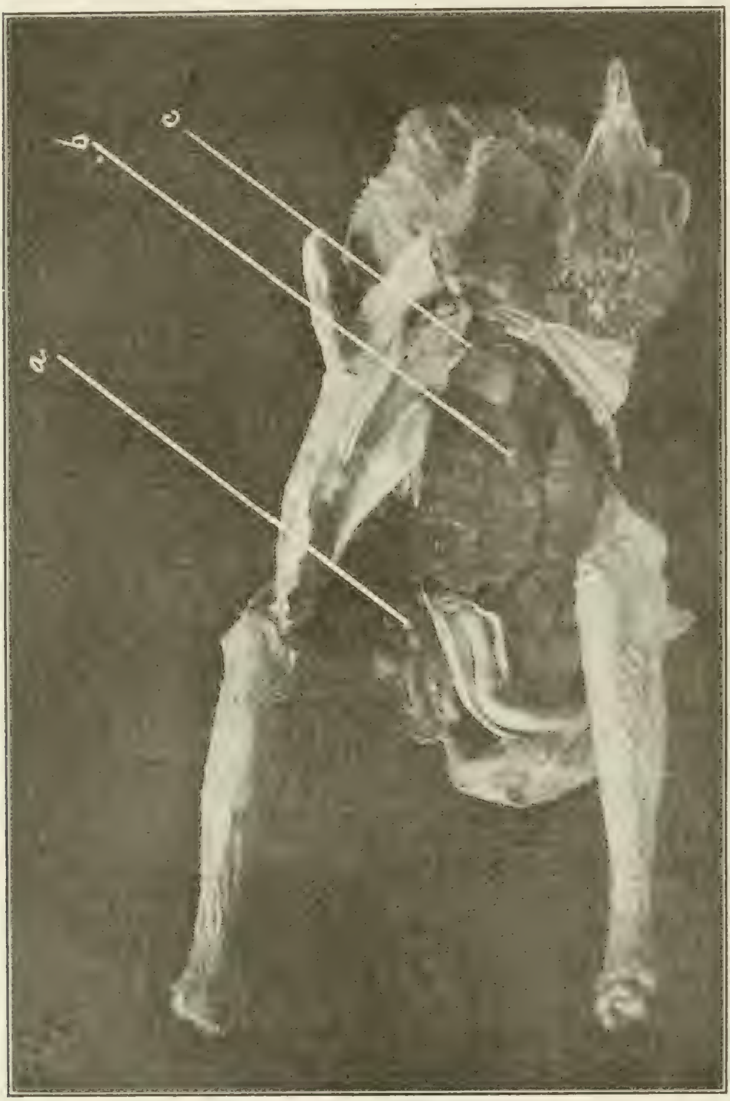


Fig. 1. A Tuberculous Chicken. *a*, a tubercle in the wall of the intestine; *b*, a tubercle in the liver tissue; *c* tuberculous lung tissue.—Orig.

It is true that the prolonged cooking to which fowls are subjected before being eaten surely kills the bacteria, but the house wife or cook upon whom falls the task of drawing the intestines and other viscera is almost sure to contaminate the fingers with tubercle bacteria if the bird is affected. When we remember that ordinary washing of the hands

neither kills nor removes all these bacteria, it is easy to understand how they may reach the mouth or food that is not subsequently cooked. The tubercle bacteria have also been found in the white of the egg. Fortunately, however, the affected chickens soon cease to lay. The eating of eggs from tuberculous hens, raw or only partially cooked, as when

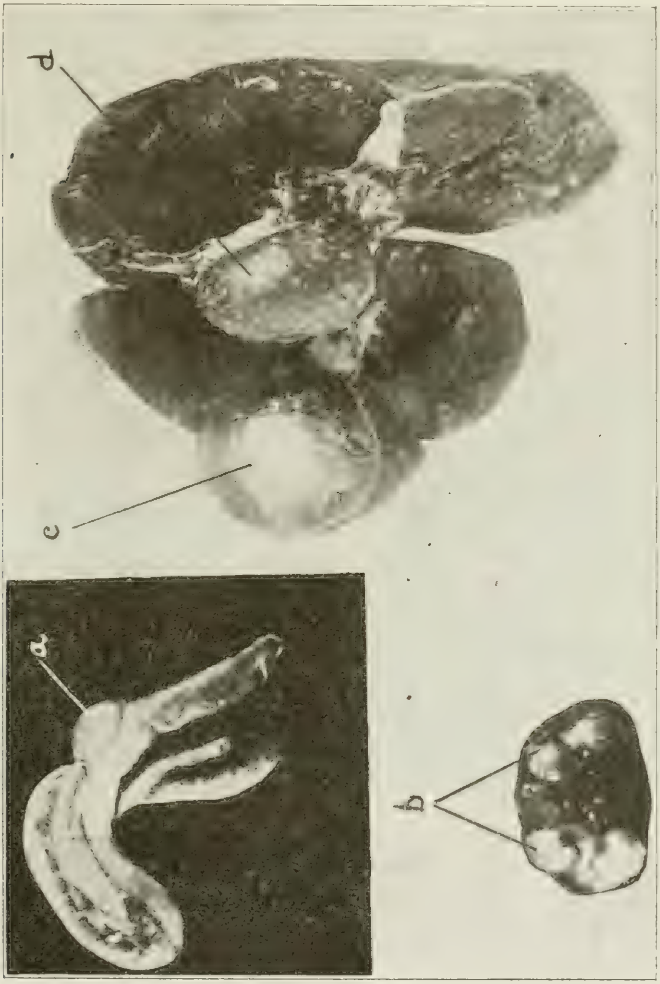


Fig. 2. *a, b, c* tubercles in wall of intestines, in spleen, and in liver respectively; *d*, tubercles in spleen. Orig.

the white is left uncoagulated, may result in taking living tubercle bacteria into the body.

The symptoms of tuberculosis in chickens are not sufficiently characteristic to permit of a positive diagnosis, but they may lead to a strong suspicion. Appetite may remain until a few days before death, emaciation becomes extreme, feathers are ruffled, the fowl is weak and dumpish, moving about little. The eyes may be bright, though sunken. The comb and wattles become pale and flabby, and the mucous mem-

branes of eye and mouth are pale. The temperature usually remains normal (about 106.5° to 108.5° F.). Occasionally, the bird shows lameness as a result of a tuberculous joint or bone. This may be mistaken for rheumatism. At times, there are tuberculous nodules of the skin, especially about the head. The bird may be affected several weeks before any of these symptoms appear. (Fig. 1.) The tissues most frequently affected are the liver, then the spleen, intestines, mesentery and rarely the lungs, kidneys, ovary, oviduct and subcutaneous tissue, and at times the joints and bones. The tubercular masses vary greatly in size, ranging from mere specks to the size of a large pea, and they may be few in number or thickly sprinkled throughout the organ. (Fig. 2.) They are usually of a yellowish-white appearance and are easily separated from the surrounding tissue. They tend to break down in the center and, if in the intestinal wall or oviduct, may communicate with the passage into which they discharge numerous tubercle bacteria.

The bacteria are very numerous in the diseased tissue, much more so than in human or bovine tuberculosis. They probably leave the body almost entirely through the alvine discharges and enter with the food almost exclusively. The feeding habits of chickens tend to rapidly spread the disease, and failure to keep pens constantly clean and disinfected increases the chances of infection.

There are a great many affections that may be mistaken by a casual observer for tuberculosis. Especially is this true of diseases of the liver or nodules in other organs. The liver disease may be due to fatty deposits, coccidia or other protozoa, as in black head, pus-producing bacteria, fungi, or tumors of a malignant nature as cancer. A careful microscopic examination is necessary to determine the exact nature of any of these conditions. With any disease, it is important to find out early the exact nature of the trouble. Any suspicious cases should be sent to this laboratory for diagnosis.

There is positively no known treatment of any value for tuberculosis of chickens. When a positive diagnosis has been made, the best solution of the problem seems to be to kill the whole flock and use those not affected for food, burning the diseased ones. After this, a careful disinfection of the chicken house and yards is necessary before it is safe to introduce new birds. As a preventive, may be recommended the exclusion of the disease by raising stock from eggs known to have come from healthy birds, and refusal to buy stock from poultrymen that cannot offer evidence of flocks free from tuberculosis. Expert advice covering each individual case should be secured since circumstances might alter the procedure greatly. With those finding the disease, this laboratory will gladly coöperate in its eradication. In this way, it may be possible to adapt the methods employed to the exigencies of the case.

BACTERIOLOGICAL LABORATORY.

WINTER VETCH FOR A COVER CROP IN MICHIGAN ORCHARDS.

Circular No. 13.

Most of the successful orchards in Michigan are plowed in the spring and cultivated until mid-summer. This season is the natural one for trees to make a growth of new wood and the plowing and cultivating

Winter Vetch, sown Aug. 1, 1910. Photographed Oct. 12, 1910. Thirty pounds of seed was sown broadcast.

Same Orchard as shown in picture at left. Photographed May 25, 1911.

make the plant food in the soil available and stimulate the growth. After the cultivation ceases, the new growth will ripen, become hard and in a condition to pass through the average winter without injury, which it could not do if growth continued late in the fall.

At the last cultivation, it is desirable to sow something that will make a "cover crop" on the land during the fall, winter and early part of the spring. If nothing is sown, weeds will make a "cover," but they will not make a uniform growth nor will they result in any benefit to the land and they may become a serious annoyance.

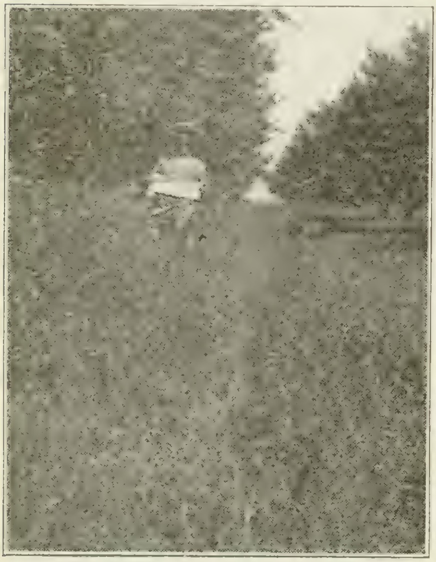
Many desirable features will result from having a cover crop in an orchard or vineyard, some of the more important ones are:

1. Their growth helps to check the tree growth and ripen the new wood.

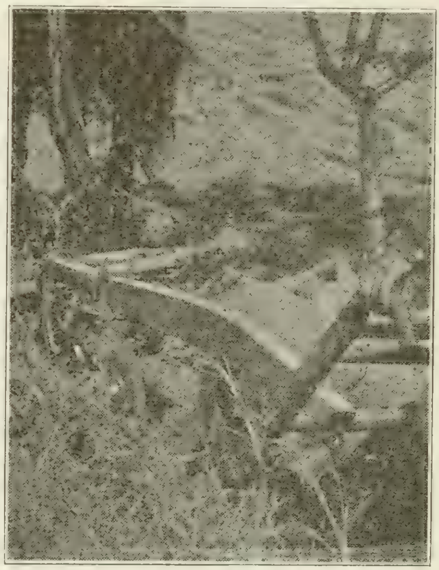
2. A cover of vegetable growth over the soil, supplemented by the root system will prevent, to a very large extent, the washing of the valuable top soil by the heavy fall and spring rains. This feature is especially valuable on knolls and hillsides.

3. A cover crop will catch and hold the leaves as they fall from the trees. They contain some fertility and afford some protection.

4. The cover crop itself will make a blanket over the soil and by holding the snow from blowing away, this feature will be more effective, as it will largely prevent deep and severe freezing of the roots and the alternate freezing and thawing, all of which causes serious losses



Eighteen pounds of Winter Vetch seed per acre was drilled in this apple orchard in Aug., 1910. Photographed May 17, 1911.



By using a rolling coulter no trouble to get a large growth of vetch turned under.

in many Michigan orchards, especially those located upon the lighter and more porous soils.

5. One of the most valuable results from the use of cover crops is that they add humus and plant food to the soil. Certain plants commonly used for cover crops as clover, vetches, peas and beans, possess the power of gathering nitrogen from the air, storing it in the plants and later it becomes available in the soil.

Some of the advantages of the cover crop that might be mentioned are: That they encourage the deep rooting of trees; they make the fall and spring operations in the orchard more comfortable and they improve the physical condition of the soil.

A plant suitable for an orchard or vineyard "cover crop" must meet some unusual demands. It must make at least a fair growth during

late summer and fall; it must be able to stand the tramping necessary at picking time; it must be able to withstand a possible drought; in most cases in Michigan, it must live over winter and grow vigorously in the spring; it must be hardy and it should have the power to gather nitrogen from the air and hold it in the roots.

The Experiment Station has been carrying on tests in orchards and vineyards in different parts of the state to determine the best plant for a cover crop under Michigan conditions. At this time, Winter Vetch (Vicia villosa) promises to be especially valuable for this purpose. The plant is sometimes called Hairy or Sand Vetch. It was imported from Europe many years ago and has long been used in the southern states especially as a forage crop. An appreciation of its value for orchard cover crop purposes is comparatively recent.

When sown as late as the middle of August, it makes a fair growth before winter; it will stand tramping well; it is not difficult to get started; it is hardy and will withstand the possible drought of fall and cold of winter; it grows vigorously, in the early spring; it adds a large amount of nitrogen to the soil; it will succeed on a variety of soils and especially well on sandy soil.

Michigan fruit growers who have not tried this plant for a cover crop are urged to do so. Seed should be ordered at once as practically all that is used in this country, is imported from Europe and the supply is limited.

For cover crop purposes in Michigan, the seed should be sown during July or early August, usually at the time of the last harrowing.

If the seed is sown broadcast about 25 to 30 pounds to the acre is required and it should be harrowed in. Good results have been secured by drilling 18 pounds of seed per acre.

A quick growth or "catch crop" can be secured by sowing a bushel of oats or rye with the vetch. Since the vetch does not make a large growth in the fall, this combination is often desirable.

There will not be any difficulty in turning under the vetch if the orchards are plowed at the proper time in the spring. Where the growth is extra large, a chain or rolling coulter may have to be used on the plow.

H. J. EUSTACE,
Horticulturist.

TOP WORKING APPLE TREES.

Circular No. 14.

When a bearing orchard contains undesirable varieties and the trees are sound and healthy, it is often advisable to top-work them. This consists of grafting the branches with scions of a more desirable variety and thus changing the entire bearing surface of the tree into a different variety.

Selection of Scions. Scions (Fig. 2A.) are selected from bearing trees of the desired variety. They are cut preferably in late fall or early winter although they may be cut any time before the buds swell in the spring. Only wood from bearing branches of the past season's growth is selected and after cutting them into lengths of eight to twelve inches, they are plainly labeled and tied into bunches of convenient size. They should then be packed in sand or sawdust and stored in a cool cellar or some place to prevent them from starting into growth before grafting.

Time to graft. The trees may be grafted any time in the spring before the sap begins to flow. It is generally performed about the time the trees are ordinarily pruned in the spring. If the trees are not grafted at this time and the scions are kept dormant in some cool place as an ice house, the grafting may be successfully done later in the spring when pruning may be performed without serious bleeding.

The most important factor in top-working large trees is the selection of the branches to form the top. Scions when grafted upon horizontal branches, instead of continuing to grow in the direction of the original branch, always grow upward. This tends to produce a narrow high-topped tree. Great care should be exercised, therefore, in selecting branches well away from the trunk and covering all the fruit-bearing surface of the tree. The branches should not exceed an inch and a half in diameter at the point of graftage as scions seem to prove more successful on branches of this size. In top-working an old tree about one-third of the branches that are to be grafted should be worked each year as the cutting of more branches in a single season would prove too severe. It will, therefore, take three to five years to renew the entire top. Where the fruit bearing surface is large, this will often necessitate the making of ten to twenty grafts each season for about three successive years. All the important branches should be grafted, and it is safer to graft too many branches and be obliged to cut out a few in later years than not to graft enough.

How to Make the Graft. In top-working mature trees, the cleft graft is the form generally used.

With a pruning saw, a branch an inch to an inch and a half in diameter is cut, being careful not to loosen or tear the bark on the stub. If the saw is coarse, the stub may be dressed with a sharp knife which will tend to hasten the callousing. A grafting tool as shown in Fig. 1 may

be made by any local blacksmith from an old file and will be found more serviceable than the other forms now on the market. The important characteristics of this tool are the heavy curved blade sharpened on the inner side and the wedge on the end placed well away from the back of the blade. In using this tool, the curved blade prevents the unnecessary loosening of the bark in making the cleft and therefore, is better than one with a straight blade. The stub is split with this tool just enough to accommodate the scions. The cleft is then held open with the small wedge and two trimmed scions are placed in the cleft as seen in Fig. 2b. Each scion should contain about three buds and the lower end of the scion should be trimmed with a sharp knife to a wedge about 1 to 1½ inches long with the outer edge of the wedge thicker than the other (Fig. 2a.). It is very important that the sides

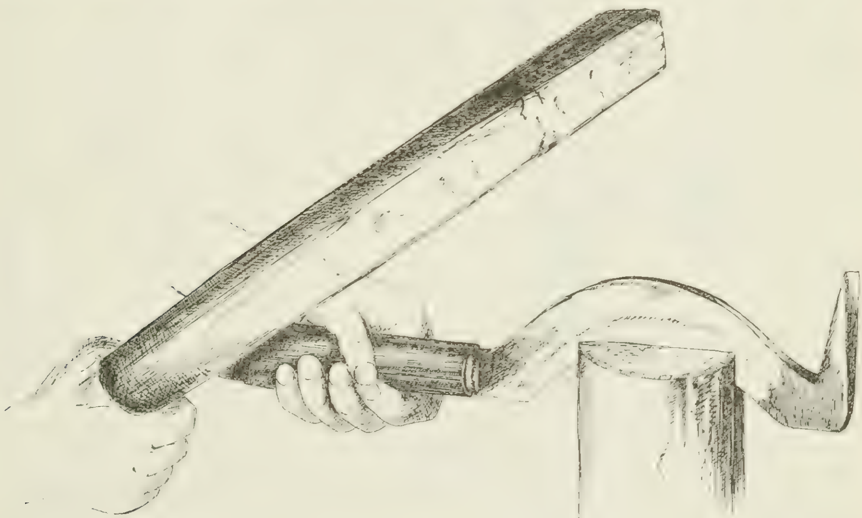


Fig. 1.
CLEFT GRAFTING.—Making the cleft with grafting tool and mallet.

of this wedge be cut perfectly even. As the union of the scion and stock takes place at the cambium layer or inner bark, it is also important in making the graft, to have the inner bark of the scion in contact with the inner bark of the stock. Hence the scion is left a little thicker on the outside edge to insure the pressure of the stock against the scion at this point. (Fig. 2c.) Frequently the scion is tipped slightly outward that the cambium layers may be in contact at least at one point. In preparing the scion, it is also advisable to trim it in such a manner as to have a bud just above the wedge on the thicker side, so that when it is placed in the stock, it will appear just above the cleft on the outside. After the scions are trimmed and placed in the stock, the wedged end of the grafting tool may be released from the cleft and the graft is then ready to wax. Pulling the wax out into wide ribbons, the sides of the cleft are first covered and then the entire upper surface of the stub is carefully covered, being especially

careful to press the wax firmly around the scions. This will prevent the stock and scions from drying out. Likewise the tips of the scions may be covered with wax.

If both of the grafts grow, the weaker one should be cut out the following spring to prevent the formation of a crotch, and the stub, if not entirely healed may be covered again with wax.

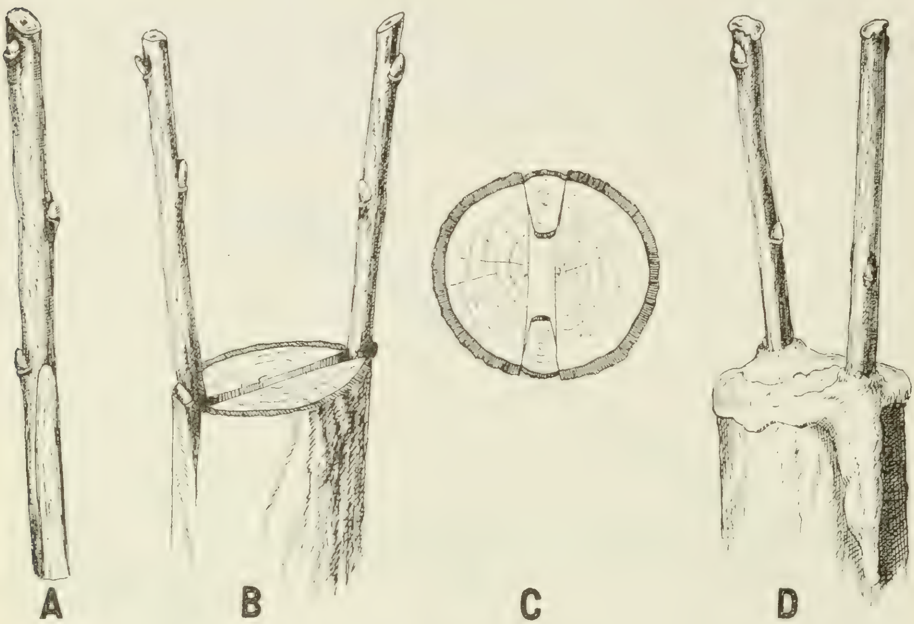


Fig. 2.

CLEFT GRAFTING.—(a) Scion; (b) Scion inserted in cleft; (c) Cross-section of stock and scions; (d) Cleft-graft waxed.

Making the Wax. A good grafting wax is made from the following formula:

4 pounds of resin.
2 pounds of beeswax.
1 pound of beef tallow.

Pulverize the resin and cut up the beeswax and tallow.

Boil together slowly until all is entirely dissolved. Pour this into a pail of cold water and after greasing the hands, squeeze all the water out of the wax and pull like one would molasses candy until the wax becomes light-colored. Then, if wrapped in oil paper, it may be stored until needed. In cold weather, when the wax becomes very hard to work, it should be slightly heated before using.

C. P. HALLIGAN,
Assistant Horticulturist.

POTATO CULTURE.

THE SOIL AND ITS PREPARATION.

Circular No. 15.

A well drained sandy loam is ideal for potatoes. Such a soil should, if possible be included in a regular rotation and the potato crop follow a clover sod which should be turned under in the fall, or early in the spring. When fall plowed, the sod will partly decay by spring and there will be an opportunity to work the soil several times with both disc and harrow before planting, which is very important. It has been demonstrated many times that much better crops can be produced upon a soil that has had this extra working than when it has not been given.

Always avoid low fields where the frost may destroy the plants early in the fall before the growth has been completed.

THE SEED.

Whole tubers about the size of a hen's egg are very satisfactory for seed, especially so in a dry season. If such seed is not available use cut pieces about the size of a hen's egg and have at least two good eyes on every piece. Larger seed pieces may give a larger yield but not enough to pay for the extra amount of seed required, especially if it is expensive.

If any of the seed is "scabby" even to a very slight degree, it should be treated by soaking for two hours in a solution made up in the proportions of one pint of formalin to thirty gallons water. Formalin can be procured from any druggist. Do this shortly before planting and before the seed is cut. Do not put the treated seed back into crates or bags that held the tubers before treatment, unless the crates are washed and the bags soaked in the solution. The scab disease may live in the soil for some years, so do not plant upon land that recently grew scabby potatoes or beets if it can be avoided.

FERTILIZERS.

The best fertilizer for the potato crop is undoubtedly stable manure spread upon a clover sod before plowing in the fall. If spring plowed, spread the manure on during the winter or early spring. The plowed-under clover will in itself make a good fertilizer.

If it is desired to use a chemical fertilizer, our experiments made during the past few years indicate that a "home mixed" fertilizer containing 4% nitrogen, 7% phosphoric acid, and 10.8% potash used at the rate

of 500 lbs. per acre is the most satisfactory. A ton of this fertilizer is made by mixing:

193	lbs. nitrate of soda containing 15.5% nitrogen.
357	lbs. dried blood containing 14% nitrogen.
1,000	lbs. phosphoric acid containing 14% nitrogen.
450	lbs. sulphate of potash containing 48% nitrogen.
2,000	lbs. "home mixed" potato fertilizer.

It should not be overlooked that the value of a chemical fertilizer depends largely upon the physical condition of the soil, the moisture content as well as proper drainage and cultivation. Even very heavy applications of fertilizers will not make up for the lack of any of these conditions nor will the use of any kind of chemical fertilizer take the place of the humus or decayed organic matter in the soil.

PLANTING.

Where the planting is done by hand, furrows may be opened with team and one horse plow and if any chemical fertilizer is to be used it can be spread in the furrow by hand. On light or loose soils it is desirable to plant the seed about four to six inches deep. If shallow planted some of the potatoes will become exposed and sun burn. The seed pieces are dropped the distance desired, covered with a hoe, and the whole field smoothed over with a harrow.

It would be profitable to use machine planters upon large acreages (over ten acres) and with these a fertilizer attachment is often used to distribute the fertilizer. If the planter is not equipped with such an attachment the fertilizer may be drilled in with an ordinary drill before the field is planted, or can be spread by hand.

The distance for planting depends upon the fertility of the soil, but rows three feet apart and from 18 to 24 inches in the row has given good results on an average soil. With intensive cultivation and a rich soil, they may be planted as close as one foot in the rows.

CULTIVATION.

Frequent cultivation will greatly help to produce a good crop and keep the field free from weeds. A spike tooth harrow is usually used once or twice before the plants come up and again just as they appear. A weeder is often used at this time and about once a week afterward until the plants are several inches high. During this time it may be advisable to go over the field once or twice with a cultivator. After the plants are five or six inches high cultivate about once a week or every ten days until there is danger of injury to the vines.

SPRAYING.

Potato plants are sprayed with Bordeaux mixture (6 pounds of copper sulphate, 5 pounds of stone lime and 50 gallons of water) to protect them from blight and rot (*Phytophthora infestans*) and with poison (½ pound of paris green or 2 or 3 pounds of arsenate of lead added to

the Bordeaux) to kill bugs. The blight and rot are not present every season in Michigan, but in tests made at the College during several recent seasons, it has paid to spray the plants when blight has not been present. The application of Bordeaux mixture in some way stimulates the plant and it grows longer in the fall, is freer from sun scald, tip burn and other troubles. Begin spraying when the plants are six or eight inches high or when the first spraying for "bugs" has to be made and repeat the treatment about every two weeks so that the new growth will be covered with the Bordeaux mixture. If the weather is "muggy," conditions under which blight flourishes, spray oftener. Four or five sprayings will usually be sufficient and they can be made for 80 cents to $1.00 per acre for each spraying, all expenses of material and labor included.

HARVESTING.

Do not dig until the vines are dead (except early varieties may be dug when large enough to be marketable) if dug before the tubers "skin" and are not as salable. If the plants have been killed by the blight, delay digging until about ten days after the tops have died, by this time the disease will have run its course and the potatoes that are left will be sound and keep in storage.

Dig when the soil is dry, and pick the potatoes up as soon as they have dried off. Cool dark cellars are very satisfactory for storage. Pits are good, but often difficult to open when wanted.

H. J. EUSTACE,
Horticulturist.

SANDY SOILS OF WESTERN AND NORTHERN MICHIGAN.

Circular No. 16.

At the present time considerable areas of sandy soil are being offered for sale in Michigan. Many calls for information concerning the value and management of such soils are coming to the college. This circular is prepared to provide in a concise way the information asked for.

These soils range from the coarser Dune sands to the finer Miami fine sands. The greater part of the soils offered for sale are properly embraced under what is known as Miami sands.

The Dune sands possess little or no agricultural value.

The Miami fine sandy soils are sufficiently valuable for agricultural purposes to require little attention in this place.

The Miami sands vary from soils that possess much intrinsic agricultural value to soils that can never be made profitably productive under ordinary methods of management.

INTRINSIC VALUE.

The value of Miami sand will depend chiefly upon four things:

1. Its origin. Whether made up largely of material produced from the breaking down of granitic rocks and other rocks rich in plant food constituents, or whether made up of material chiefly siliceous—pure quartz.

2. Upon the fineness of the material. The finer the material the greater is its waterholding capacity and the greater, also, the amounts of plant foods which it will give up for the use of the plant.

3. The subsoil. The finer the subsoil the more valuable are these lands for cropping purposes. It is not an uncommon thing to find areas of these Miami sands so coarse in appearance as to cause the observer to wonder at the excellent crops which they produce. The secret is found usually in an underlying subsoil of clay located 18 to 60 inches below the surface, and having a depth of a few to several feet. This subsoil of clay is of value in that:

> (a) It acts as a reservoir to hold the water in the soil above, and in itself, which otherwise would disappear downward by gravity, and
>
> (b) In that when close enough to the surface the roots of the growing crop above find their way into the clay itself, and thus procure a larger supply of plant food.

4. The distance of the water table from the surface, regardless of the kind of underlying subsoil. That is, the distance which we should have to dig or drive to secure a well.

INDICATIONS OF CROPPING VALUES.

The possible cropping value of these lands is indicated by the original vegetation which they are supporting or have supported.

1. Nearly all of these sands originally coverd by hard wood such as maple, oak, beach, elm, etc., can be depended upon to produce fair to good crops.

2. Areas which originally supported good growths of white pine usually prove reasonably productive, and for some crops such as potatoes and clover, quite productive.

3. Areas originally covered with Norway pine are uncertain.

4. Areas originally covered with Jack pine can rarely be depended upon for profitable crops, and never under ordinary methods of soil management.

5. Where the original forest vegetation has been removed the productiveness of these soils is indicated by the density of the growth of grass, shrubs, brakes, and other plants which occupy the ground.

It sometimes happens that the prospective purchaser of wild lands may form a fair estimate of the cropping value by observing the crops growing upon near-by cultivated areas having the same formation.

CROPS.

The crops best suited to these soils are: potatoes, clover, rye, buckwheat, and in some cases wheat, oats and barley. Truck crops do well; corn and beans do fairly well. Alfalfa promises to prove a very valuable crop for these soils. They are not adapted to the growing of sugar beets.

Mr. O. K. White says of these soils:

Peaches, grapes, cherries, raspberries, blackberries, strawberries, and a few varieties of apples, pears, and plums can be grown profitably upon a sandy soil, if:

1. The location provides sufficient air drainage so that the trees, bushes, fruit buds, or crops are secure from severe winter freezing, or late spring frosts and early fall frosts, as the case may be.

2. The location has good natural surface and soil drainage.

3. The soil is deep and fertile and underlaid with a strong subsoil of clay or loam so that it will support a healthy vigorous growth.

4. The soil is so managed as to conserve moisture and maintain a fertile condition by the judicial use of barnyard manures, cover crops, and commercial fertilizers.

MANAGEMENT.

In the handling of these soils the farmer should keep in mind always the great importance of the presence of organic matter in the soil. To this end he should adopt methods that will result in introducing into and retaining in these soils the greatest possible amount of organic matter.

CLEARING AND BREAKING.

In clearing these lands all logs and loose stumps should be hauled off and disposed of by burning or otherwise. Logs and stumps should not be burned in place. The rotten portions of logs and stumps should be retained and scattered over the surface. The surface should not be burned over but all material that can possibly be plowed under should

be carefully saved. The best time for breaking is said to be the month of July after all vegetation has reached its full growth, but before the perennial plants have begun to store up food material in roots or stems for future use.

In breaking, a chain should be used to assist in covering up all vegetable material. The depth of the first plowing, according to the best authorities, should not much exceed four inches. The depth should be sufficient to cover the material being plowed under, but if possible without turning up the subsoil. This leaves the organic matter near the surface where it belongs, to anchor the soil, and to be most available and most useful to the future crop. It is recommended that the plow be followed with a heavy roller, and the roller with a light drag.

A very excellent thing would be to seed this land at once with 30 pounds per acre of winter vetch seed which, if the rainfall is normal should produce a good growth before winter, thus filling the soil with roots and increasing the soil's nitrogen supply. This growth will protect the soil from the winds which might otherwise, and in many cases would disturb the surface soil. It will also help to hold the snow of winter. In the spring the vetch should be thoroughly disced into the soil or plowed under, thus improving the soil in several ways for the crop which is to follow.

LATER MANAGEMENT.

After the land has been brought under cultivation, great care must still be exercised in its management. The cropping value of these soils will depend more than anything else upon the incorporation and retention of organic matter. To this end a careful rotation of crops should be adopted. It should be simple and *short*, something like this:

(1) Clover, one or two years, plowing under as much of the after-growth as is possible when preparing for the succeeding crop; (2) a cultivated crop,—potatoes, corn, or possibly beans, and (3) grain of some kind, seeding again to clover with grain.

This is not the only rotation that could be followed, but the important thing is to introduce clover into the rotation as frequently as possible. No grain or cultivated crop should be planted twice in succession.

The plowing should be shallow, probably never to exceed *five* inches, and this with a view to keeping the organic matter as near the surface as possible where it will accomplish the most good, particularly in protecting the soils from the ravages of the winds. It is good practice not to use the plow too frequently. Many farmers use the plow only in breaking the clover sod. The disc harrow is used at all other times in preparing soil for crops.

When cultivated crops occupy the land, the cultivation should be frequent and shallow. Only those who have practiced persistent shallow cultivation can appreciate the importance of thus stirring the soil in preserving the moisture and insuring profitable crops.

Use "catch" crops where possible. If a regular crop has been removed fairly early in the fall and the succeeding crop is not to be planted until the following spring, it is always worth while to seed the land to oats or rye or vetch. Frequently it will be found desirable and profitable

just before the last cultivation of the corn to seed the corn field to winter vetch at the rate of 30 pounds per acre. The field may be seeded to oats or rye instead. The benefits to be derived from the catch crop are at least three:

1. In the fall and early spring the soil is protected from the winds.
2. During the winter these crops catch and retain the snow upon the ground, from which fact the soil benefits not only from the blanket of snow during the winter, but, also, from the melting of the snow in place in the spring.
3. The discing in of the crop in the spring adds to the soil organic matter, and in the case of vetch, nitrogen as well.

GREEN MANURING.

Green manuring is the practice of growing a crop to plow under before it matures. This is done to increase the amount of organic matter in the soil. Different crops are used for this purpose.

Rye is perhaps the most commonly used, and probably chiefly because it can be planted in the fall and makes a considerable growth before the growing season closes. It takes up the growth again early in spring and continues until the farmer is ready to plow it under. It is sown at the rate of 1½ bushels to 2 bushels per acre.

Of the spring grown crops oats or rye are frequently used, and are sown at the regular rates of seeding.

Sometimes Indian corn is sown at the rate of 1 bushel to 1½ bushels per acre for this purpose. It may be sown in drills or broadcast.

Oats and peas are sometimes used, sown at the rate of 1 bushel of oats and 2 bushels of peas to the acre.

Sand vetch is also used, the seeding being at the rate of 30 to 50 pounds per acre. The seeding in all cases is done as early as conditions of soil and air are suitable for the planting of the crop.

The sand, hairy or winter vetch seems to be rapidly growing in favor, both as a catch crop plant and as a green manuring plant. Its value rests upon three things, viz.:

1. Because of the size of the seed it may be planted as deep as two inches, thus increasing its chances for moisture supply, and thus insuring germination. The clovers and alfalfa frequently suffer because they may not be planted deep enough to insure moisture and anchorage to preserve the plant from blowing away.
2. The plant makes a very rapid and vigorous growth, producing a large amount of material to plow under or disc in.
3. It is much more valuable than the grains for this purpose because of the amount of nitrogen which it gathers during its growth and leaves for the use of future crops.

On the Miami sandy soils of southern Michigan the cow pea is being much used as a green manuring crop. Peas are sown at the rate of 3 pecks per acre, about the first week in June, and the crop is plowed under from the first to the middle of September. When wheat is sown after cow peas thus plowed under, the yields of wheat are greatly increased; and when clover is seeded with the wheat the following spring, it seldom fails to make an excellent catch.

LIVE STOCK.

The keeping of live stock on these lands is very important: First because much of the material that would otherwise be sold from the farm is retained for feed, and from 65% to 80% of the feed will reach the manure pile. In the second place these lands are said to respond to a remarkable degree to the application of manures. The manures, therefore, should be carefully husbanded and applied to the soils. Where the land is to be plowed, it will be found best to apply the manure as a top dressing after the plowing has been done. Where the land is to be disced, the manure should be applied before the discing, and it will usually be found best to apply the manure a considerable time, if possible, before the discing is done.

ALFALFA.

It has been shown that many of these soils are especially adapted to the growing of alfalfa. Alfalfa will prove not only a very valuable crop so far as yield and feeding value are concerned, but it will, also, prove very beneficial to the soil itself.

TOOLS.

For these soils, after they are brought under cultivation, the following tools will be needed:

1. Plow, of the long mold-board type.
2. Disc harrow. The 18 inch disc is usually considered best.
3. A land roller.
4. Spike tooth harrow of the lever type and of light weight.
5. Weeder.
6. Cultivator of the small, many-shoveled or toothed type.

The disc harrow will be used instead of the plow in preparing the ground for the crop, excepting where the crop is to follow clover.

The roller will be needed usually only where the plowing immediately precedes the planting, or where a crop of some kind is plowed under.

FERTILIZERS.

Commercial fertilizers cannot be made to take the place of organic matter in these soils. In general farm practice the greatest value can be gotten from commercial fertilizers only when such a system as outlined above is practiced; but with such system, and with proper fertilizer it is probable that profitable results may be obtained from their use. In buying prepared fertilizers it is best to buy the higher grades of fertilizers; for the cost per pound of available plant food in the high grade fertilizers is less than that in the low grade.

—J. A. JEFFERY.

THE MICHIGAN WOODLOT.

FARM FORESTRY.

Circular No. 17.

The area of the average Michigan woodlot is 14.14 acres or 15% of the area of the average farm in the state, which is 91.5 acres. The best authorities have considered that a forest area of at least 20% should be maintained to exert a favorable influence on climate and to supply market demands.

The scope of farm forestry is several fold, including the following, viz: Economic maintenance of the wooded areas on the farm which are already in good condition, until such time as the increased price of land makes a more intensive use advisable; location of new forest areas in the form of windbreaks and shelter belts so that not only the wood yield can be considered when figuring returns, but also the value of the growth as a shelter and for its aesthetic importance to the general farm surroundings. Still another activity may be the planting to prevent erosion and land slides on steep hillsides where the object is soil retention. Special phases of farm forestry may be indulged in where conditions are favorable and larger returns made than can be hoped for on original woodlots and plantations, i. e., Christmas tree nurseries and basket willow holts.

PRESENT CONDITION OF WOODLOTS.

Deplorable conditions, in many instances, exist in the old woodlots, the last remnants of the virgin forests in the southern part of the state. In most cases, they are composed of a wide mixture of species, mostly of mature individuals rapidly decreasing in value. No attention has been paid to the efforts of the forest to reproduce itself; pasturing has been carried on indiscriminately and the young growth has been browsed and trampled out. Wind and excess of sunlight have been admitted by cutting the first trees at hand when needed, with no thought of regulation.

In striking contrast with these conditions, are those found in the best type of virgin forest. The wind and excess light are retarded by an almost complete crown cover aided by the growth of low, well-leaved branches on the extreme boundaries of the forested area where sunlight is abundant. Under these conditions, the forest floor was formed. The leaves which ripened each season were not blown away but fell gently to the ground under the trees which bore them. Yearly, more leaves, needles and twigs were added, until a heavy covering of forest litter was formed, which held the moisture from melting snows and summer rains. Millions of tree seeds were deposited each season in the moist bed of low, slowly changing temperature. These seeds remained dormant but vital for long periods, no one knows how long. When sunlight was admitted by

breaking the crown cover, the seeds long dormant, germinated and populated the forest, and again in turn, kept out the sunlight and protected the forest floor.

INVOICING STOCK ON HAND.

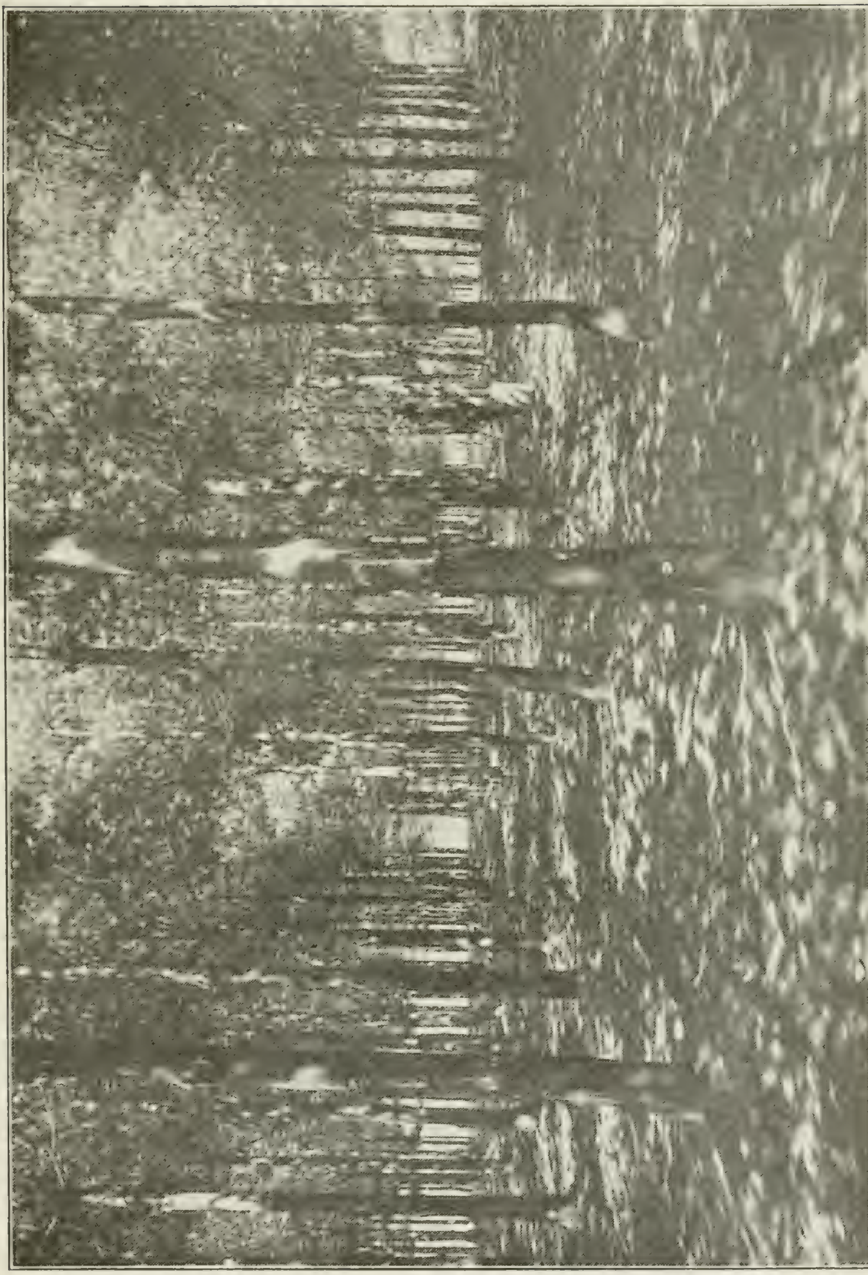
Whether buying, selling or retaining a farm, it is well to know the condition and volume of timber on hand in the farm woodlot. Farms are frequently sold and a large part of the purchase price is paid by selling timber off the woodlot.

The pioneer farmer who usually spent several months each year logging could tell, at sight, the content of logs or trees in board feet and cords. The younger generation should never cut a tree without first making at least a mental note of its contents. Better yet, keep a record of the trees cut each season, noting their diameters breast high, species and their actual yield. Such a record should be referred to when observing the general condition of the woods. There are several rules of thumb which are convenient aids in calculating the volume of trees and logs and which give results close enough for practical purposes. (1) Estimate the number of sixteen foot logs in the tree and apply the following formula to the diameter at the small end of each log inside the bark: viz., subtract 4 inches, square one-fourth the remainder and multiply the result by the length which will give you the contents of the log in board feet Doyle rule. To reduce this to cords, divide by 550. (2) Measure the diameter of the tree breast high, calculate the basal area, multiply by the height and divide by 2, which gives roughly, the cubical content of the tree. Reduce to cords by dividing by 128. The average stacked cord 8x4x4 ft. contains 70 per cent of solid wood. (3) Measure the breast high diameter, square it, multiply the result by 2 and divide by 10, which will give the cubic feet in the particular tree. To determine the board feet, multiply by 8.

To determine the stand on any given area, measure the breast height diameters of all the trees, group them according to unit classes, multiply the number of trees in each diameter class by the diameter class itself, add the results and divide it by the total number of trees in all the classes, which will give the approximate diameter of an average tree. Fell this tree and apply Doyle's formula; also cut and stack the crown wood and measure in actual cords; then multiply the separate volumes thus obtained by the number of trees in the stand, thus roughly determining the stand in board feet and cords. Other rule may be substituted for Doyle if desired.

PROTECTION.

The important enemies of the farm woodlot are grazing animals, wind and fire. The woodlot to be used as a productive forest, must not be used as a shady pasture. Stock browse and trample out the young growth. Standing at the base of large trees or among saplings, horses, cattle, and sheep repeatedly stamp the earth, breaking the root fibers and puddle heavy soils in wet weather, making them impervious to rain. The litter of the forest floor is broken up and is thus more easily transported by the wind. In the pastured woodlot, the tree growth is checked; in many cases where the soil has been puddled badly, the



I. White Pine planted in 1897 on an exhausted gravel pit. Ideal forest conditions now exist.

trees become stag headed and finally die. The hog is the only animal on the farm which may be of benefit to the woodlot. Where the woodlot has a well littered forest floor and reproduction is not abundant under good light conditions, turn in the hogs after the nuts and acorns fall in the autumn until freezing weather. The hogs will tear up the surface mixing the leaf mold with the mineral soil also embedding a portion of the nuts and acorns in the mixture. Under these conditions, the chances for abundant reproduction the spring after a heavy seed year, are very good. After this reproduction has been secured, keep the hogs out. If the woodlot is in a vigorous productive condition, it is worthy of as good a fence as the clover field.

Wind does greater damage to small isolated patches of timber than any other factor. In early spring it blows over shallow rooted trees when the soil is still moist and carries away the litter of the forest floor, thus leaving the seedlings bare and subject to killing by the alternate freezing and thawing and heaving of the soil. The hot wind of the summer, sweeping through the timber, dries out the soil and hardens it retarding the growth of old trees and in many cases, actually killing seedlings and saplings.

In winter, the snow in a well protected forest lies evenly, thaws gradually and thus has time to soak into the ground. In a wind swept area of timber, the snow will be carried through and dropped on the edge of the lee side of the woods; here it will bank up until the warm spring days when it will thaw rapidly and run off, eroding the fields, filling drains and causing floods.

Nature provides a wind break on the boundaries of all woods by the large leaved branches formed in the sunlight and the forest seedlings in the form of undergrowth which develops most vigorously where light is abundant. Nature's protection thus formed should never be broken except in very small areas and then only gradually.

If it were not for recurring fires, the cut over pineries of the north would doubtless now be clothed with a young forest growth of almost priceless value. Michigan would then look forward to sending out pine from her boundaries as of old, instead of bringing it in from the south and west.

Fire was the greatest aid to the early settler in land clearing, when timber was of slight value, but by the time timber values began to rise, the careless use of fire had become a habit. Even now, farmers permit their slashings to burn for days unattended when a strong wind might cause a fire which would wipe out a community, as has actually been the case several times in our state. Fire protective associations have been formed by large lumber companies and the public in general is rapidly beginning to realize the great importance of efficient protection to timber lands. Usually the fire risk is extremely low in cases of isolated woodlots away from railroads and camping places. It is useless to endeavor to protect timber growth within 150 feet of the right of way of a railroad, especially on main lines. Fire lanes should be formed by clearing off a strip 150 feet wide and keeping it under clean culture. Branches too small for fuel left after cutting should be either piled and burned in an open space or lopped and spread so as to come in close contact with the damp earth of the forest floor, thus hastening decay.

II. Windbreak of White Pine established fifteen years ago on the west boundary of the College farm. Sturdy transplants were spaced 12x12 feet apart and clean culture given for the first three years.

Causes of fires should be ascertained and damages secured to inculcate in careless individuals and railroad companies, the importance of great care.

In cases where woodlots are adjacent to towns, cities or car lines, much annoyance is caused by trespassers, pot hunters and boys who are usually little skilled with the proper use of a gun. Besides destroying the bird life of the woodlot which should be the pride of every farmer, cases have arisen where valuable stock has been seriously injured by misdirected shooting. The whole country should organize to stop such trespassing and do away with this actual danger to the country community.

Much damage has also been done to growing timber by draining adjacent farm lands. Such damage is unavoidable and is but the result of extending the cultivated areas. The damage may be far reaching, extending to areas some distance from the lands being drained. The old timber in such cases is unable to adjust itself to new conditions—trees become stag headed and either die outright or make but a very slight growth. Such has been the case over large areas of Black Ash and Tamarack swamps until these two species are almost commercially extinct. In the case of the Tamarack, the sawfly has also been a direct cause of diminishing the present stand.

CUTTING.

The relation of trees to each other should be carefully observed. Thinning should be light and frequent and made at intervals according to a continuous, definite plan. The density of the stand should be determined by the density of the crowns. Never admit sufficient light to permit the abundant growth of grass or the encroachment of briars. Thinning should be made early but not until the resulting saplings will in part at least pay the expense of cutting, as used for fuel.

Tree weeds should be eliminated from the forest growth as rapidly as conditions will warrant. They are usually short lived dwarf species of quick growth of very little or no commercial value, which occupy space and utilize the moisture and plant food which should go to developing the more important commercial species. Such species as Blue Beech and Witch Hazel are practically worthless as far as their wood is concerned while Ironwood, Dogwood and Thorn Apples grow to large sizes and are much used for making small utensils, bolster stakes, wagon reaches, etc. Aspen or trembling poplar, while of large commercial importance in the manufacture of paper pulp, is usually considered as a weed of the woodlot as it does not attain a large size and makes but a poor grade of fuel. Other species such as Juneberry, Alder, Pin Cherry and Sumach should be cut, making room for more valuable species as rapidly as possible.

In cutting for market, where the woodlot is to be maintained, it should be carried on by a selection system. This, too, should follow the same continuous plan as thinning. Cut the dead and down timber first, then the injured trees and those which are or soon will be conflicting. Work toward a single species or a desired combination of species. Cut in the winter when snow is on the ground so falling timber will not injure the seedlings and young growth. The harvesting of timber should be spread over a series of years, thus avoiding a radical change in the make-up of the forest. Each year's cut should be as nearly the same as possible.

III. A dense stand of Hard Maple in the sapling stage; much in need of careful thinning. The condition of the forest floor is excellent. Neither stock nor fire have been allowed to damage this area since the mature growth was removed.

REPRODUCTION.

Where forest conditions approach somewhat the ideal and the forest floor is in receptive condition for seeds, it will not be difficult to get natural reproduction.

Natural reproduction can be greatly aided by artificial seeding. In the fall, spud in seeds of beech, walnut, hickory, oak acorns and chestnuts in open places among the other trees and along the boundaries where the light is sufficient. In order to plant lighter seeds, the forest litter may be scraped away to the mineral soil, a few seeds scattered in and a light coating of litter returned to place. Such seeds as those of the three Elms, Red and Silver Maple may be planted in spring while a great variety of conifers and many others of the broad leaf trees may be planted in this way in the fall with little effort.

Where more rapid results are desired, seedlings or transplants grown in the home garden or procured from a nursery may be set directly into place.

ESTABLISHMENT OF NEW WOODS.

In establishing new woods, wherever possible, they should be located so as to utilize untillable land, beautify the home surroundings, protect buildings, orchards, or fields, while at the same time, they are laying up wood material which may finally be utilized for fuel, fence posts, implement handles or possibly building timbers.

Many a farm has found a purchaser at a premium over the adjacent one because of a Norway Spruce wind break or a few well placed stately elms by the road side. It has been the tree planting and tree admiring families who have stayed generation after generation on the farm.

Most farms of the average size have small areas which on account of their position or drainage conditions, are not fit for cultivation. The soil on these areas may be as fertile as that on the adjacent cultivated field and if planted to trees would produce a good growth. With the constant rise in price of lands, it will pay sometime in the future, doubtless, to drain and perhaps terrace these acres. Until then, they should be growing timber. Steep hillsides may not only be unproductive but may be the cause of damage to adjacent lands by erosion, the washing of soil and depositing it on land under cultivation. In such locations tree growth aids in retaining the soil in position while the volume of lumber constantly increases. On such areas, planting should be made dense and cutting should be very gradual by the selection system.

In establishing windbreaks and shelter belts, spacing is one of the important points which goes far in determining the success or failure of the work. In general, space wide on light soils and dry locations and close on more fertile moist areas. Shade enduring trees will permit of closer spacing than light demanding species. Original cost of stock may also be an influential factor, as with close spacing the cost increases rapidly, as is shown by the following table of spacing and number of plants used:

Feet.	Plants per acre.
3 x 3	4,840
4 x 4	2,723
5 x 5	1,743
6 x 6	1,210
7 x 7	889

IV. Remnants of mixed hardwood growth which has been cut from time to time. Damage from wind, fire and stock has resulted in an unproductive woodlot. These same conditions exist in many farm woodlots throughout the state.

For windbreaks, space the rows six feet apart with the trees four feet apart in the rows, alternating; for shelter belts 100 feet wide, planting four feet apart each way, proves satisfactory.

In the establishment of windbreaks and shelter belts where conditions are favorable for soil preparation and clean culture as for corn, given during the first three years, it will permit the use of smaller planting stock and stimulate the growth. Where intensive soil culture is not feasible, larger planting stock should be used.

If shade is desired in the pasture, group a few Carolina Poplars or other rapid growing species, on a ridge, north slope or in a field corner, planting ten feet apart each way in such a position as not to hinder cultivation. In five years, these will make a continuous shade, under the group at midday in summer. These poplars are of quick growth and short lived and should be pruned to form crowns eight feet from the ground, headed back frequently to thicken and spread the crown. The grove should be protected by temporary fence for the first five years. Stock stamping beneath these trees will doubtless eventually kill them out. New groves can easily be established in other portions of the field when it is observed the original group is deteriorating.

SPECIES AND SOILS.

In a large measure, the success of tree planting lies in the skill of the planter to determine the adaptability of a given species to certain sites and soils. The true guide is the natural conditions under which a given species is found growing in virgin forests within its natural range.

There are seventy indigenous tree species in this state from which to choose. It is generally best to utilize native trees rather than exotics. The following trees are a few species of commercial importance which do well under average conditions in this region. The Norway Spruce and European Larch have been planted extensively and have been found to do remarkably well in this state. Austrian and Scotch Pine also have been much used but are not equal to some of our native species which can be planted for the same purpose.

Norway Spruce is one of the best trees for general windbreak planting. It grows dense, does well on medium and light, well drained soils and is a much more rapid grower than our native White Spruce. It is, perhaps more extensively planted than any other introduced species in the central west.

White Pine. This is a tree well known to those familiar with tree growth in the Lake States. It originally made up the largest part of our coniferous forests of the north and was found more or less throughout the state. It makes a good growth on well drained loam also on sandy soils which are not too light. It does not grow as dense as the Norway Spruce but is a good windbreak and shelter belt tree. The timber now brings the highest price of any of the pines.

Eastern Hemlock. This is one of the most beautiful conifers for general planting on the home grounds. Under natural forest conditions it is usually found associated with Birch, Basswood, Beech and Maple. It does best on damp rich soils, is apt to become open and thin branched with age and the limbs are subject to breaking by heavy snows. It

V. Carolina Poplar four growing seasons from a ten-inch cutting. This tree will give quick results where shade is wanted for stock in pastures. The crown should be headed back slightly each season to make it spread out.

grows slowly and is more adapted for planting where clipped hedges are desired or isolated trees are wanted on lawns than for extensive windbreaks or shelter belts. The wood is inferior in quality and could be but little used in general farm operations.

European Larch. This is another foreigner, a native of Tyrol and much planted in the Highlands of Scotland. It, however, very much resembles our native Tamarack. It was introduced into this country about sixty years ago and extensively planted in the central west. The tree is a rapid grower. The timber is durable and strong and could be used for fence posts and doubtless could take the place of Tamarack in silo building. It does well on a great variety of soils.

White Cedar. This tree was once very common in our northern swamps where it grows in close stands. It is of very dense slow growth on deep rich soils and could be used for windbreak planting on truck lands. The wood of this tree furnishes the larger proportion of our fence posts.

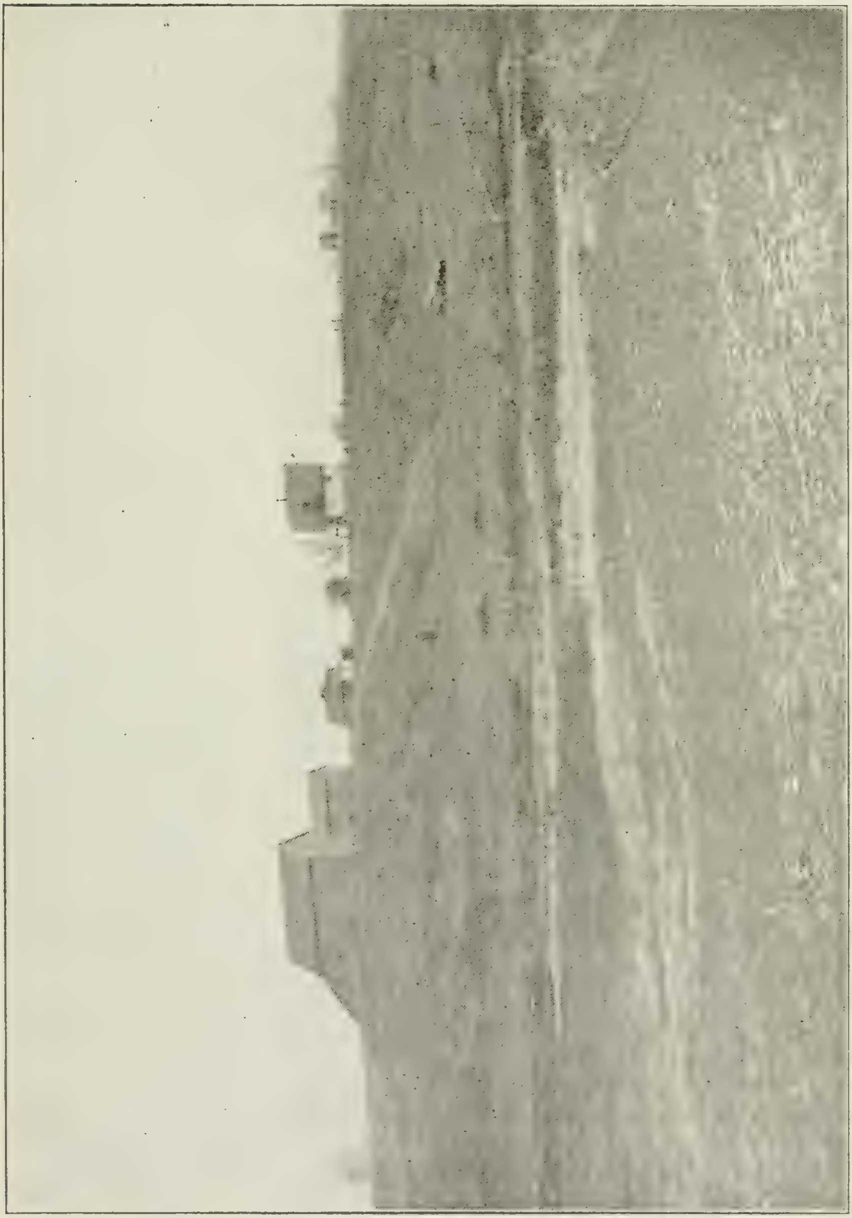
Red Oak is the most rapid grower of all the oaks, is exceptionally wind firm, will endure a high degree of shade in its early development and is thus adapted to underplanting in open spaces in the woodlot. It sprouts profusely from the stumps after being cut, and does well on light soils. The wood is strong, hard, moderately durable and therefore, has a wide range of uses on the farm.

Carolina Poplar is a variously named tree of rapid growth adapting itself to a great range of soil conditions but making the best growth where moisture is abundant. Without doubt, it is the most vigorous grower which will thrive in this state. Trees seventeen years old have attained a diameter of fifteen to seventeen inches and a height of approximately sixty feet; fifteen year old trees have grown twelve inches in diameter and approximately fifty feet high. Like all the poplars, it demands light and therefore, would not be a desirable tree to plant among others where it was apt to be shaded to any extent. It is propagated by cuttings with great ease.. It is one of the best trees for planting on embankments and hill sides to retain the soil and prevent erosion. The wood is light, soft and makes good, cheap lumber.

Black Locust is a vigorous grower on light to medium, well drained soils. It is easily reproduced from seed which it bears abundantly or from root suckers and sprouts. It develops best in full sunlight and will endure shade moderately. It is a short lived tree being in many cases, badly attacked by the Locust borer. The wood is hard, tenacious, very durable in contact with the soil, making excellent material for fence posts.

Hard Maple is one of the most beautiful and extensively planted trees for shade as well as one of the most common trees of the farm woodlot. It is a tree of slow growth, doing best on well drained, gravelly loam. It will withstand shade to a marked degree and is thus excellent for underplanting. The wood is hard, strong and produces a high quality of fuel. Commercially it is much used for building purposes and also in the manufacture of implements, tools, etc.

Black Walnut develops rapidly on rich, moist soil and will not bear shading. Trees under favorable conditions will bear nuts at ten years of age. The wood is hard, strong, coarse textured and is at present, the



VI. Heavy clay hill sides badly gullied. The best remedy is to plant such areas to rapidly growing trees which will form a mass of fibrous roots and thus keep the soil in place.

highest priced of the state's native hardwood, being much sought as a cabinet wood.

White Ash makes a fairly rapid growth on medium well drained soils. Seedlings will start in dense shade but must have excess light at an early age. It produces seed abundantly and is easily propagated. The wood is tough, strong, and elastic and is much used for all sorts of implements.

American Elm is more commonly planted and admired as a shade tree than any other of our natives. It attains its best development on rich soils and will stand shading. The seeds are usually produced in great abundance in late June and have a low rate of germination and should be planted at once. For shade trees along roadsides, plant forty feet apart alternating.

Basswood is a fairly rapid grower on deep moist soils, and will withstand moderate shading. It can be easily reproduced from cuttings, sprouts or seed which it bears abundantly. It is one of the best honey producing trees and should be planted abundantly in apiaries. The wood is white, streaked with brown heart, is easily worked and could be much used for light lumber on the farm.

White Willow thrives on moist locations where it grows with great rapidity. It demands light to a marked degree and should never be used for under planting. It is easily reproduced by cuttings and will produce a windbreak or shelter belt in moist locations quickly. Much light wood for summer fuel can be produced by pollarding.

STATE COOPERATIVE WOODLOT WORK.

Under the ruling of the State Board of Agriculture, the College Forestry department is authorized to furnish seedlings to land owners at a low rate to induce tree planting. The department now maintains a forest nursery of thirty acres well stocked with seedlings and transplants of vigorous growth and such variety of species that stock can be furnished adapted to a great variety of conditions. Lists will be set on application.

—J. FRED BAKER.

DRAINAGE.

Special Bulletin No. 56.

Need for drainage is indicated when water stands at or near the surface of the soil sufficiently long (1) to interfere with farm operations in the way of tillage, planting or harvesting or (2) to render the soils soggy or compact.

Three things are essential to the growing of good crops, so far as the physical condition of the soil is concerned, viz.:

The right condition of temperature.

The right condition of moisture.

Sufficient ventilation.

The seed of our ordinary crops will germinate most rapidly when the temperature ranges from 75 to 95 degrees F., depending upon the crop. They will not germinate vigorously at a temperature below 60 degrees, nor much above 100 degrees.

The vigor of the growth of the future plant will be modified quite materially by the rate of germination.

In a soil with a surface temperature as low as 60 degrees the rate of plant feeding will be low, as will also be the rate of nitrification and free nitrogen fixing.

It requires much more heat to warm an over wet soil than it does to warm the same soil with the best amount of moisture for the growing of crops.

If a soil is kept over wet because of improper or insufficient drainage much of this moisture will disappear into the air by evaporation.

From a soil in proper moisture condition as much as ten tons per acre may evaporate into the air in twenty-four hours in ordinary weather. In very windy weather this amount may be increased. With the soil over wet as much as thirty tons have been known to evaporate from an acre in twenty-four hours in early spring weather.

In the evaporation of a single pound of water as much heat is used as would raise 966 pounds of water one degree in temperature, and in the evaporation of a ton of water from our fields an amount of heat is used sufficient to heat the soil on an acre one foot deep, including twenty per cent of moisture (which is not far from the average optimum amount of moisture for the growing of crops,) over one and one-quarter degrees. If, in one of these over-wet fields, the excess of evaporation amounted to only ten tons per day enough heat is used to heat the soil as indicated above over twelve degrees, so that the waste of sunshine that should be used in warming the soil is very great indeed.

Soil must be ventilated for the same reasons that our houses must be ventilated; namely, to keep up a proper supply of oxygen in the soil and to remove from the soil undesirable gases which are deposited in the soil by the germination of seeds, the growth of roots, etc., etc., and in

addition the soil must be ventilated in some cases to keep up the supply of nitrogen.

Seeds will not germinate in the absence of oxygen. Plants not only will not grow when their roots are not supplied with oxygen, but will actually die because of its absence. The nitrifiers (the organisms in the soil that transform the nitrogen of the organic matter into nitric acid, which is so essential for the support of our domestic plants) cannot carry on their work in the absence of oxygen.

On the other hand there is another class of organisms found in the soil, which, when oxygen is absent from the soil, will destroy those forms of nitrogen which have been prepared or are in process of preparation for our domestic plants. These organisms have been known to destroy as much as six hundred pounds of potassium nitrate per acre in three weeks in a water-logged soil. These organisms are known as denitrifiers.

Free nitrogen fixers, the organisms found in the nodules on the roots of clovers, beans, peas, and other legumes, take the free nitrogen of the air in the soil and combine it with oxygen and hydrogen to form nitric acid. These organisms must have the supply of nitrogen provided with which to work, and must be supplied with oxygen to assist them in carrying on their work. Two much water in the soil excludes the air.

The roots of ordinary crops cannot grow under water. Under best conditions the roots of corn plants will grow to a depth of ten to fifteen or more feet. The roots of oats will grow to a depth of six to ten or more feet, as will also the roots of clover. If, therefore, water stands within three feet of the surface of the ground when the root systems of these crops are developing, the area which these roots may occupy is much restricted.

Soil puddles, or "bakes," when water is allowed to stand in or upon it. This puddling helps to exclude the air and at the same time offers resistance to the development of the root systems of plants. It lessens the power of the soil to hold water useful to plants and at the same time increases the tendency to loss by evaporation. Puddled soils crack in drying and thus again restrict root development, or in case roots are already occupying the soil, the roots are broken.

Ordinarily a soil that is properly drained and properly tilled becomes sufficiently mellow to a proper depth to permit the most complete development of the root systems of our crops. Because it is mellow its capacity for moisture in proper condition for the use of plants is greatly increased, so that, paradoxical as it may seem at first thought, a well drained soil will, in dry weather, produce a much better crop than will an undrained soil of the same type.

LANDS LIKELY TO NEED DRAINAGE.

1. Low lying flat areas, and especially those more or less surrounded by hills.

2. Higher areas of open soils with comparatively slight slopes and underlaid by rather imperious sub-soils.

3. Heavy clay soils even though they have apparently considerable natural surface drainage, but more especially when the surface is marked by slight depressions, from which the water cannot drain readily.

4. It frequently happens that in regions generally well drained there

occur small areas underlaid by nearly impervious strata of clay sub-soil. These isolated areas may be found well up on the sides of slopes and occasionally on the top of the highest portions of fields. Such areas may not contain more than a few square rods and yet so persistently is the water held that the planting of crops is delayed and in some seasons actually prevented. One such area amounting to one hundred square rods existed at one time at the highest point of a twenty acre field on the College farm.

5. Springy places that occur at the foot of slopes, and not infrequently, well up on the sides of slopes.

TILE.

Two general kinds of tile are to be found on the market, the so-called common or porous tile and glazed tile. Both of these are manufactured in lengths of twelve inches and in diameters ranging from three inches up to fifteen or more. Occasionally we find tile manufactured in diameters of two inches. The two-inch tile, however, is not much used at this time.

The glazed tile is doubtless more durable than the porous, but a well burned porous tile made of good material will last for centuries if placed below the frost line.

Even the best made porous tile is likely to shell if subjected to freezing, and both the porous and the glazed tile will crack if the water filling them should freeze.

Within the past few years the manufacture of cement tile has become somewhat common, and several machines for the manufacture of cement tile are now on the market. There are cases reported of cement tile that has been used for many years, twenty or more, and it appears to be as good as it was at the time of making.

HOW THE WATER ENTERS THE TILE.

In the case of glazed tile the water can enter the tile only by way of the joints.

In the case of porous tile, in all but the heavier clay soils, the greater part of the water enters the tile by way of the joints, and perhaps this may be true even in the case of the heavier clays. In a recent experiment it was shown that in the case of porous tile laid in lines four rods apart the rate of flow through the walls of six-inch tile was two tons per acre in thirty hours, while in the case of four-inch tile laid in the same way the rate was 1.55 tons per acre in thirty hours. In these cases the tile was very hard and of the porous kind. With four-inch common, more porous tile laid in the same manner as above, the rate of flow was 1.66 tons per acre in thirty hours. In the case of four-inch cement tile laid in the same manner and under the same conditions the rate of flow through the walls was twelve hundred and twenty-four tons per acre in thirty hours.

TILE SYSTEMS.

In the draining of a piece of land there are several things that should be carefully considered. It may be that a single line of tile will be sufficient to remove all surplus water from the area to be drained. This

is likely to be true if the area is not over one hundred to two hundred feet in width, provided, the soil is an open one. If the width is greater than two hundred feet or if it is as little as one hundred feet, but with a relatively impervious soil, it is probable that more than one line will

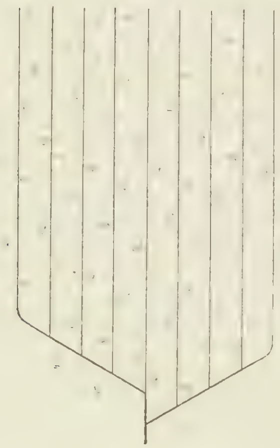


Fig. 1. One system of laying tile.

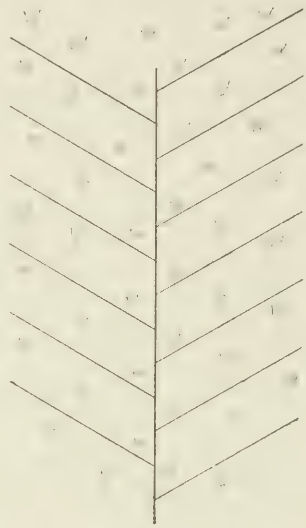


Fig. 2. A common system of laying tile.

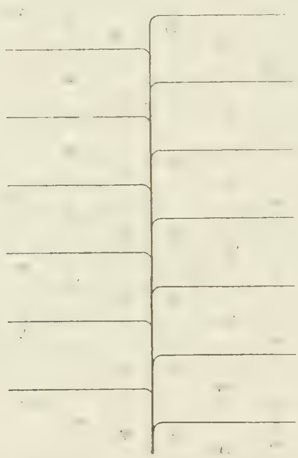


Fig. 3. In which the laterals are laid at right angles to the main.

be required. If the one line is not sufficient, then a system should be introduced, and the style of the system will depend upon the surface of the area, the shape of the area and possibly upon the notion of the one who is installing the system.

Figures 1, 2, and 3, illustrate two general systems employed in tile drainage. All sorts of combinations of these are found in actual prac-

tice. See Fig. 4. In any system of tile, that line which receives the water from all the other parts of the system is called the main and all the lines receiving water directly from the soil and conveying it to the main are called laterals. If there should be more than one system of laterals, each system flowing into another line than the main, which in turn carries the water to the main, this other line we call a sub-main. Figure 4 illustrates this point.

OUTLET.

The point at which the main discharges its water is called the outlet. The efficiency of a tile system and the expense of installing such a system will depend very much upon the location and the construction

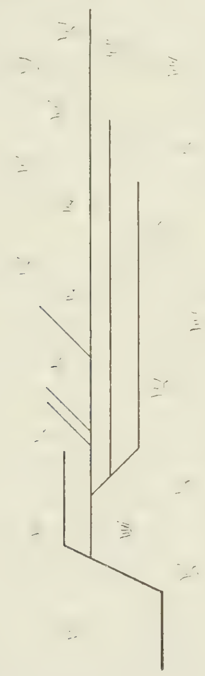


Fig. 4. A combination of the systems shown in Fig. 1 and Fig. 2, in operation on the college farm.

of the outlet. Generally the outlet should be so located that the main shall extend through the lowest portion of the area to be drained and that the main can be placed with the least amount of digging, and have the fewest possible angles in its course. It should be so located that ordinary outside water should not stand as high as the bottom of the tile.

DEPTH.

It is desirable that tile drains shall lie about three feet below the surface. It sometimes happens that in fields with uneven surfaces, or where it is difficult to get the proper amount of fall, the tile must be laid in places as close to the surface as eighteen inches. Tile placed too

near the surface is subject to freezing, and freezing may result in the cracking of the tile or in causing a shaling of the tile, which is likely to result in its complete collapse. A depth of less than three feet fails to give to the roots of the crop a sufficient amount of room for development.

THE DISTANCE APART OF TILE DRAINS.

In very heavy clays it may be necessary to place tile drains not over thirty feet apart, while in very open soils they may be placed as far as a hundred feet apart.

In muck soils they may be placed from sixty to eighty feet apart.

In ordinary loams they may be placed from forty to sixty feet apart.

Fifty feet apart is probably a fair average.

Where the soil is underlaid with a heavier sub-soil lying so near the surface that the tile must be set down into it, the drains must be placed closer together than would be necessary if the sub soil were more nearly like the soil above in openness.

SIZE OF TILE TO USE.

Ordinary drain tile ranges in size from two inches up to twelve and even to fifteen inches.

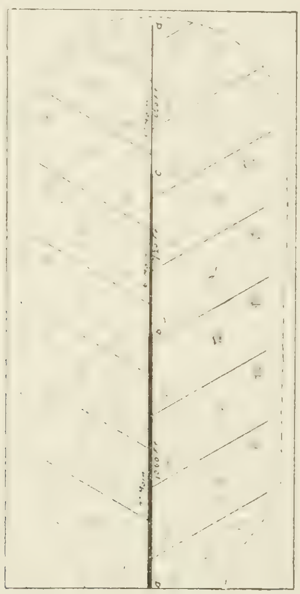


Fig. 5. The lower 1060 ft. section of main is sufficiently large to carry the water from all the field. The next 720 ft. section is large enough to carry all the water from the field above b. The upper 660 ft. section is large enough to carry all the water from the field above c.

The capacity of tile to carry water varies as to the square of the diameter. Three-inch tile will carry two and one-quarter times as much water at the same rate of flow as will two-inch tile. The square of three is nine; the square of two is four, and four is contained in nine two and one fourth times. The square of five is twenty-five. The square of

four is sixteen. Sixteen is contained in twenty-five a little more than one and one-half times and this represents the relative capacities of these two sizes of tile for carrying water.

The size of tile to be used in any instance will depend upon the area from which it is to carry water and upon whether it is to carry away only the excess of water due to rainfall on this area, or whether there is added other water brought in by springs or surface drainage or seepage from adjacent areas.

It is hardly advisable, all things considered, to use tile as small as two inches in diameter. The following general statements are quoted from C. G. Elliott, than whom there is no more practical drainage engineer in this country. These statements apply to average conditions;

"When drains are laid so that there shall be a fall of three inches per hundred feet, a three-inch tile will drain five acres and should not be of greater length than one thousand feet.

A four-inch tile will drain twelve acres.

A five-inch tile will drain twenty acres.

A six-inch tile will drain forty acres.

A seven-inch tile will drain sixty acres.

A long drain has a less carrying capacity than a short drain of the same size laid upon the same grade."

It is seen that if a long drain is to be laid, and especially if this drain be a main receiving water from laterals or other sub-mains, it will be necessary from time to time to increase the size of the tile laid as the drain approaches the outlet. Figure 5 illustrates this point.

By giving careful attention to the capacity of the various sizes of tile it is possible to exercise considerable economy in the use of the tile laid in any system.

GRADE OR FALL.

The business of any tile system is to furnish a means by which the excess of water in the soil can find the most ready means of exit.

Every system should be so laid that there is a gradual fall from the extreme end of the drain to the outlet. This fall is usually spoken of as the grade.

It is desirable where possible to have a fall of as much as three inches for every hundred feet of tile. A carefully constructed system will work successfully on a much less fall than this. Two inches is a very common grade and in very flat areas a fall as slight as one inch per hundred feet is used, and occasionally a fall of one-half inch is used.

The less the fall the greater must be the care exercised in laying the tile.

The less the fall the less will be the capacity of the tile to remove the water, and therefore the larger must be the tile used.

Elliott says: "If we double the grade per hundred feet of the drain we increase its carrying capacity about one-third." If this be true, then if we lower the grade by half we should decrease the carrying capacity by one-fourth.

It is desirable to make the fall uniform throughout the length of each line of tile. This is not always possible for reasons which will appear later. Where changes in grade must be made it is still desirable to

make the changes as few as possible and keep the grade uniform in as large sections as possible.

There is no objection whatever to changing the grade from any fall to a greater one, but care should be observed when a change is made from any fall to a less. The water moving through the drain carries with it more or less fine material which has worked its way through the joints of the tile. This material is spoken of as silt. The particles of silt are sometimes so large as to be moved but slightly by the running water in the tile—so slightly, indeed, that if the rate of flow of the water should be decreased ever so little the force of the water will then be insufficient to continue to move them. If then, in a line of tile, the fall were lessened at some point it might happen that considerable quantities of this silt would accumulate at the point of change. Sometimes this does happen to the extent that the tile is clogged, unless some means is provided to prevent the clogging.

SILT BASINS.

Silt basins (see Figs. 6, 7 and 8) are chambers or openings established at intervals along a tile system for the purpose first, of gathering the silt moved down the tile by the drain water, and second, as means

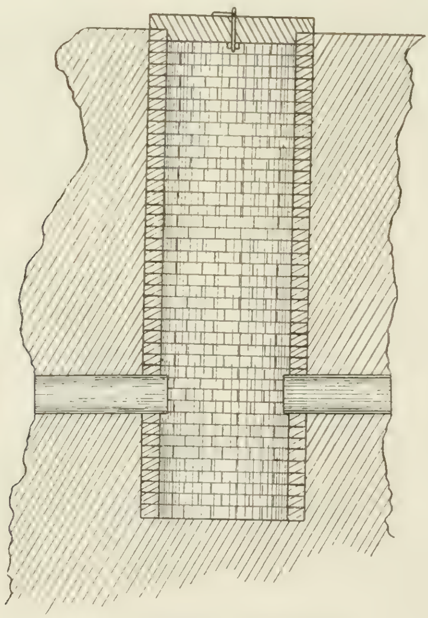


Fig. 6. Silt basin built of brick.

for examining the condition of the tile system. In extensive systems, a silt basin should be placed at any point where the fall is reduced, where a sub-main unites with a main, where a long lateral unites with the main or submain, and at intervals along any considerable line of tile, whether it be lateral, sub-main or main.

The bottom of the silt basin should stand at least a foot below the lower edge of the tile and the basin should be at least twelve inches in diameter,

and should be eighteen to twenty-four inches in diameter for large tile. As the water enters the silt basin from the tile its velocity is suddenly decreased and its capacity to carry silt is reduced. Most of the silt, therefore, settles to the bottom of the silt basin as the water passes through and into the outleading tile. When the silt has accumulated sufficiently in the bottom of the silt basin, it may be removed with a shovel or a hoe.

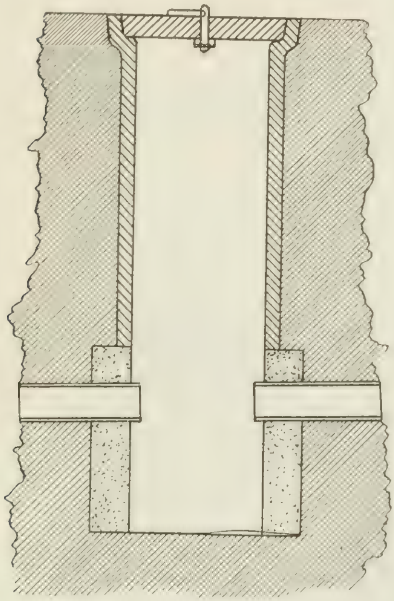


Fig. 7. Silt basin built of cement and sewer tile.

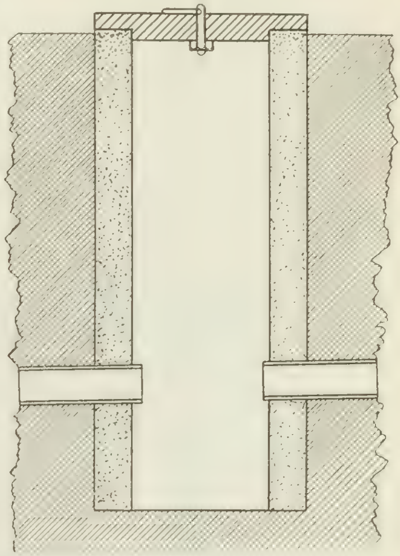


Fig. 8. Silt basin built of cement.

With silt basins placed at reasonable distances, if any section of the system fails to work properly the section can be located by an inspection of the silt basins of the system.

THE CONSTRUCTION OF A SILT BASIN.

A very common method of constructing a silt basin is to dig an opening to a depth of at least twelve inches below the bottom of the tile and from twenty to thirty inches in diameter, depending on the size of the tile leading into and from the basin. This opening is then walled or curbed with common brick to the top of the ground. See Fig. 6.

Sometimes the opening is walled with brick to just above the top of the tile and then a large piece of sewer tile of sufficient diameter is placed on end in upon the brick. Cement may be used in place of the brick. See Fig. 7.

In these days of cement a very simple method of constructing a wall for the silt basin is to set in a form and then to build a wall of concrete, using sandy gravel and cement in the proportions of seven to one. See Fig. 8.

In most cases it is desirable to carry the basin wall to a few inches

above ground. Sometimes, however, where the field is cultivated the wall is brought to within about twelve inches of the top of the ground. A heavy cover is then placed upon the top of the wall and the soil is filled in. In this case it is necessary to use some special means of locating the silt basin.

Where the wall is brought to or above the surface of the ground it should have placed upon it a substantial cover.

LEVELING.

Leveling is a process by which we determine the heights, or elevations of definite points in a line or area above an arbitrarily adopted level plane. This plane is called the datum plane. It is always so located

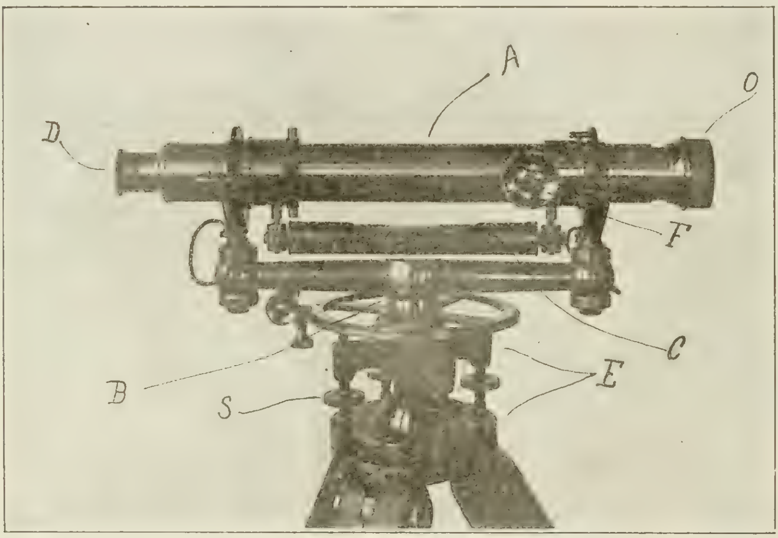


Fig. 9. Drainage level.

A telescope; B spindle; C spirit level; D eye-piece; E leveling head; F to adjust objective; O objective; S leveling screws.

as to lie lower than the lowest point whose elevation we are seeking. In ordinary practice of drainage leveling this plane is so established that the point at which the leveling begins lies just 10 feet above it—"10 feet above datum."

It will be seen then that if the datum plane is itself level and if we are able to determine the height of each stake in the line or area above the datum plane, then it is an easy matter to determine the difference in elevation between any stake and any other stake, or in other words to determine the fall between any stake and any other stake.

THE LEVEL.

The drainage level, (Fig. 9) consists of a telescope mounted on a spindle which is in turn mounted on a tripod. The telescope carries a

spirit level. When the tripod is set the spindle can be adjusted so that the telescope swinging upon the spindle is always "level."

As one looks through the telescope he sees apparently near the far end, two lines—one horizontal and the other perpendicular—crossing each other at the center of the opening. When the telescope stands level, i. e., when the level attached to the telescope indicates level:

(a) A line passing from the eye of the observer through the small opening through which he looks, and through the horizontal cross-hair is also level, and is parallel to the datum plane.

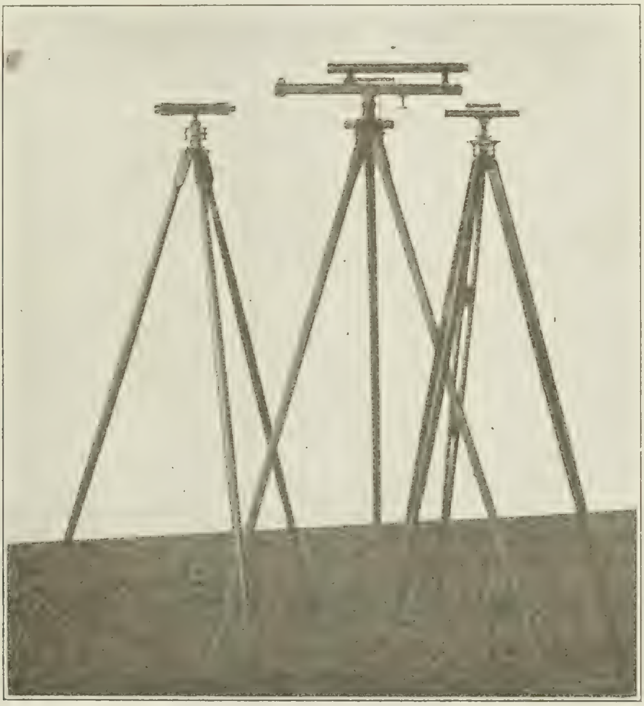


Fig. 10. Cheaper forms of drainage or grade levels. Reading from left to right:—Gurley, Jackson, Queen.

(b) The distance of the horizontal cross-hair above the datum plane is called also the height of the instrument.

(c) Every point that falls directly back of, or behind the horizontal cross-hair as the observer looks through the telescope, is the same distance above the datum plane as is the instrument.

CHEAPER LEVELS.

The instrument shown in Fig. 9 is a rather expensive instrument for one to buy who has only a limited amount of draining to do.

There are to be had a number of cheaper levels, also called drainage levels. Sometimes they are called grade levels. They are not so ac-

curately made as the more expensive instruments, but they are sufficiently accurate for use where there is a fair fall, or grade, and for other than professional engineers. Three such levels are shown in Fig. 10.

With the level there should be a leveling rod. Fig. 11 shows two such rods. One, A, is known as the sliding rod. It consists of two parts, each in this case five and one-half feet long, fitted together and clamped in such a way that they may be extended to form a rod ten feet long. A rod like A is shown extended in B. The other rod, C, consists of

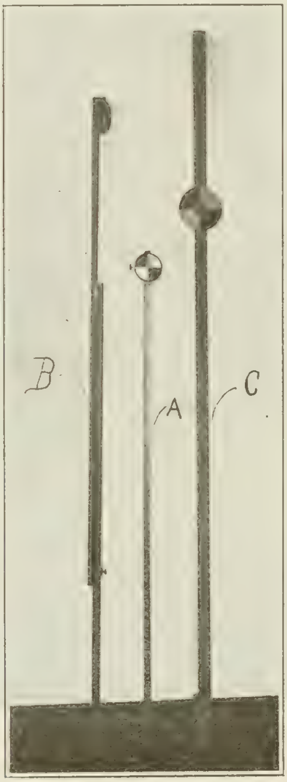


Fig. 11. Two kinds of leveling rods.

a single piece $\frac{3}{4}'' \times 1\frac{3}{4}'' \times 8$ ft. long. These rods are graduated to feet 1/10 ft. and 1/100 ft. Rods are sometimes graduated to feet, inches, and fractions of an inch.

Sometimes the face of the rod is spaced or blocked in colors, the spaces or blocks representing fractions of a foot, so that the graduated face can be read at a distance and especially through the telescope of the level. The face of rod (C) in Fig. 11 is so spaced.

Each of the rods shown in Fig. 11 is equipped with a target. The target is a circular plate divided into quarters by a horizontal and a perpendicular line, and the quarters painted red and white as shown. The target is constructed to slide up and down in grooves on the rod or upon

guides and is fitted with a clamping screw. It is open in the center to expose a portion of the face of the rod.

USING THE LEVEL.—OBJECT.

In using the level:

1. There is always a starting point whose elevation above datum is known or whose elevation above datum is arbitrarily set or, to put it more correctly, below which a datum plane is arbitrarily established. Ordinarily in simple drainage work this arbitrary height, or elevation is 10 ft.

2. There are one or more other points whose elevations are *not* known, but which it is desired to determine.

STEPS IN THE OPERATION.

To determine the elevations sought the procedure is as follows:

1. *The level is set within range of the point whose elevation is known or assumed.*

(a) The legs of the tripod are spread and firmly set in the earth so that the lower plate of the leveling head E (Fig. 9) is approximately level.

(b) The upper plate and spindle are then adjusted by the use of the thumb-screws of the leveling head so that the spirit level indicates level in whatever direction the telescope is turned. In practice the telescope is turned so that it stands in line with one pair of thumb-screws and adjustment is made with these screws to bring the telescope level. The telescope is then turned so that it stands in line with the other pair of thumb-screws and adjustment is made as before. The telescope is now turned back to its first position for readjustment, then reversed, and in each case the thumb-screws are used, if necessary, to perfect the adjustment to bring the telescope to level. When thus adjusted the telescope will stand level in all positions.

Caution.—Tighten the thumb-screws only sufficiently to hold the telescope firmly. More than this is likely to do injury to screws and plates.

2. *The height of the instrument is determined.*

(a) A leveling rod is held, by an assistant, or rodman, upon the point whose elevation is known or assumed. The rod should be held perpendicular, with face toward the level.

(b) The person in charge of the adjusted level turns the telescope toward the rod, places the eye to the eyepiece D and moves the objective O out or in until the figures upon the face of the leveling rod are clearly seen or, if the rod is too far away for that, till the view of the target is clear out. The eye piece may need adjusting to bring out the cross-hairs.

Look now to see that the spirit level indicates level, and if necessary adjust.

(c) If the figures on the leveling rod appear sufficiently clear to the one in charge of the level, as he looks through the telescope, he should read and record the height on the rod at which the horizontal cross hair crosses the face of the rod; or

(d) If the figures on the leveling rod do not appear sufficiently clear to be read by the person in charge of the level then the rod man must raise or lower the target as directed by signs from the person in charge of the level until the horizontal bisecting line of the target lies exactly behind the horizontal cross-hair of the telescope, as seen through the telescope.

The rod man should now carefully tighten the set screw of the target, and then read to the level man the height at which the horizontal bisecting line of the target crosses the face of the rod. This height the level-man should carefully record.

This reading is called the *back-sight*. *Back-sight* is the name always given to the reading taken at a point whose elevation is known or assumed and is always taken to determine the "height of the instrument."

(e) Let us suppose the reading just taken to be 4.95 ft. This means that the instrument is 4.95 ft. higher than the point at which the rod was held. Let us suppose also that the height of the point at which the rod was held is known to be 11.35 ft. above datum. If now we add 4.95 ft. to 11.35 ft. we have 16.30 ft. as the height of the instrument above datum.

3. *The height or elevation of other points within range of the level are determined.*

(a) The rod-man carries the rod to and holds it upon one of the points whose height is sought.

(b) The telescope is turned toward the rod in its new position and focussed to bring out most clearly the figures on the face of the rod.

(c) The reading is taken and recorded as in 2 (c) above. This reading is called a *fore-sight*. *Fore-sight* is the name given to the reading taken at a point whose elevation is to be determined.

(d) Let us suppose that this fore-sight reading is 4.22 ft. It means that the point at which the rod was held and whose elevations is sought is 4.22 ft. lower than the instrument—4.22 ft. nearer the datum plane than the instrument.

If then we subtract 4.22 ft. (fore-sight) from 16.30 ft. (the height of the instrument) we get 12.08 ft. as the elevation of the new point.

In like manner the rod should be placed at other points within the range of the instrument, and fore-sight readings taken. In each case subtracting its fore-sight reading from the height of the instrument gives the elevation of the point. Let us suppose two other fore-sight readings are taken and that these two readings are 3.75 ft. and 3.06 ft. respectively.

RECORDS.

Every reading should be accurately recorded in its proper place in a table provided for the purpose. If it is desired merely to find the elevation of several points, the form of table given below will serve the purpose.

TABLE I.

Point or Stake.	Back-sight.	Height of Instrument.	Fore-sight.	Elevation.
1			.....	11.35
2	4.95	16.30	4.22	12.08
3		"	3.75	12.55
4		"	3.06	13.24
5				

Observe: 1st. The elevation of point 1 had already been established (or assumed). It should be recorded after stake 1 and under elevation.

2. The back-sight, while recorded in the table after point 2, was actually taken at point 1. It is always taken at a point whose elevation has been established. It is best to record the back-sight on the line of the stake numbered nearest the stake at which back-sight is taken.

3. Back-sight reading 4.95 ft. added to the elevation of point 1, 11.35 ft. equals 16.30 ft. as the height of the instrument above datum.

4. A fore-sight reading substracted from the height of instrument gives the elevation of the point at which that sight was taken. The elevations appearing in the table are thus found.

If there are other points too high or too low or too far away, to fall within the range of the level, the level must be moved and set at a new place or station, such that one or more of these other points shall fall within its range and such, too, that one of the points whose elevations have already been found shall also lie within range of the level. The height of the instrument at this new position is now determined, the back-sight reading being taken at a point within the range and whose elevation is already found. The work from this point proceeds as above described.

Cautions: 1. Always before recording a reading observe the bubble in the spirit level to be sure that the telescope is level.

2. If at any time the level should be disturbed, it should be properly set and its height determined before taking other fore-sight readings.

USING CHEAPER KINDS OF LEVELS.

The cheaper kinds of drainage levels are of necessity more "crudely" made and cannot therefore be so delicately adjusted as the better made and more expensive instruments.

In leveling with these cheaper levels, usually only one fore-sight reading is taken with each setting-up of the instrument. One back-sight reading is also taken with each setting-up of the instrument, because the back-sight must be had to determine the height of the instrument. In using the cheaper level, the precaution should always be observed to set the instrument nearly equidistant from the point whose elevation is known and the point whose elevation is to be determined. In practice, in leveling for drains where the fall is large, it is possible, with care, to take two, three or even four fore-sight readings with each setting-up of the instrument. But here as above the level should be set very nearly midway between the point whose elevation is known and the farthest point whose elevation is to be determined with this setting of the instrument.

If but one fore-sight reading were taken with each setting of the in-

strument in determining the elevations of the points recorded in both above, the readings would appear in a table as seen below.

TABLE II.

Point or Stake.	Back-sight.	Height of Instrument.	Fore-sight.	Elevation.
1				11.35
2	4.95	16.30	4.22	12.08
3	4.87	16.95	4.40	12.55
4	5.07	17.62	4.38	13.24
5				

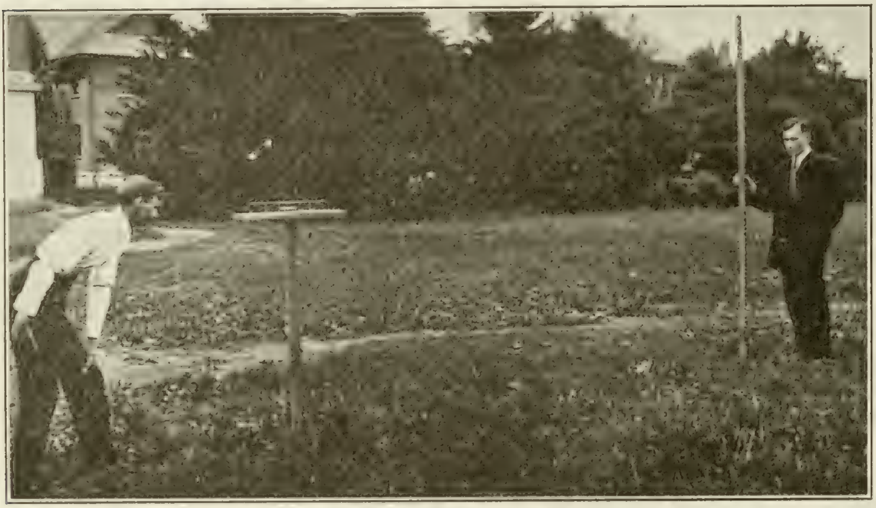


Fig. 12. Illustrating how a carpenter's level may be mounted on a stand and used for leveling.

Observe: 1. The elevation of point (1) had already been established.

2. The instrument was set once for each stake whose elevation was sought, and each time a back-sight reading and a fore-sight reading were taken and both readings were recorded in the table after the number of the point whose elevation was sought with that particular setting.

3. In each case the back-sight was taken at the point whose elevation was last previously determined.

4. In each case adding the back-sight reading to the elevation of the point at which the back-sight reading was taken gives the height of instrument and substracting the fore-sight gives the elevation of the point at which the fore-sight reading was taken.

SIMPLE DEVICES SOMETIMES USED IN LEVELING.

Where there is a good fall or where a single drain of large sized tile is to be laid on a fair fall, rather crude devices are sometimes used with satisfactory results.

There are to be had on the markets cheap leveling devices ranging from $5 to $10 in price.

A device sometimes used is illustrated in Fig. 12. It consists of a one-

legged stand, with the lower end of the leg sharpened so that it can be pushed into the ground sufficiently to hold the stand firmly upright, and so that the top of the stand shall be approximately level. Upon the top of the stand a carpenter's level is placed and, by the use of wide, thin wedges, adjusted to level. Over the top of the level thus adjusted the operator may sight. Better still, sights may be attached to the level

Fig. 13a. Illustrating the water level in use.

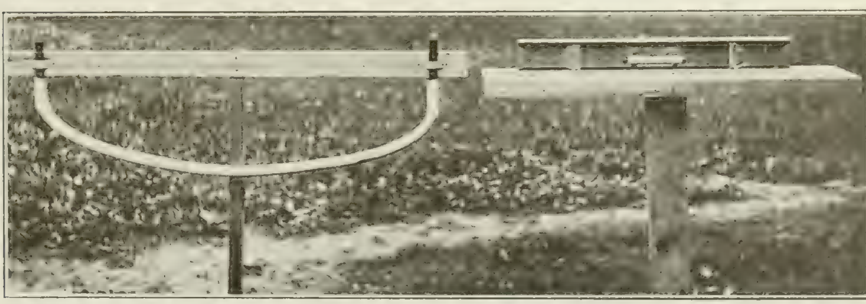


Fig. 13b. Closer view of water level and carpenter's level.

over which the operator may sight. Care must be exercised to adjust the sights so that when the level reads level the line passing over the sights shall also be level.

The so-called water-level is illustrated in Fig. 13. It consists in this case of two glass tubes firmly clamped to a bar attached to a sharpened leg. The lower ends of the tubes are connected by a piece of rubber tubing. A colored fluid is then introduced through one of the tubes until

it stands within an inch of the tops of the glass tubes, care being taken to have the bar nearly horizontal. A line passing over the tops of the columns of the fluid in the two tubes, when the fluid has come to rest is level. Sometimes horizontal sliding sights are set on the tubes. Each sight is set even, with the top of the column of fluid in its tube after the fluid has come to rest. The sighting is then done over these sights.

With these home-made devices there must go also a home-made leveling rod, the making of which will vary with the notions of the maker.

THE WORK OF PRACTICAL DRAINAGE.

Where the amount of tiling to be done ranges from a single line of tile to a system draining a moderate area, with reasonable facilities for an outlet, and with a fair fall, it is entirely practical for the farmer to do his own draining. On the other hand, when the area to be drained is large and especially when the fall must of necessity be very slight, it is usually better to place the work in the hands of a practical drainage engineer.

In any case the work should be taken up about as outlined below.

LOCATING THE OUTLET.

The first thing to be done is to locate the point of outlet somewhat as previously indicated. See page 7.

LAYING OUT THE DRAIN—GRADE STAKES.

Beginning at the outlet the main line of the system should be established by driving stakes at intervals of fifty feet.

These stakes should be about one inch by one and one-half inch, ten inches long and pointed. In clay soils eight inches is long enough, while in the looser soils such as mucks, it may be necessary to have them from twelve to fifteen inches long. They should be driven in straight lines about two inches back from the intended edge of the ditch. They should all be driven on the same side of the ditch at least this shou'd be true for any one section of the drain. They should be driven so that the tops stand about one inch above the ground in each case, and to secure uniformity in height it is a good plan to carry a small piece of ⅞-inch board, six inches, by twelve inches, and to lay this board on the ground next to the stake and drive the stake until its top shall stand just even with the upper surface of the board. In this way the effects of the little inequalities in the soil are overcome. These stakes should be driven so that their greatest width stands parallel with the edge of the drain.

FINDERS.

Three or four inches back from each grade stake should be driven another stake commonly called a finder. This stake should be eighteen inches to two feet long, seven-eighths inch thick, and two to three inches wide, and should be driven from four to six inches into the ground.

These stakes assist in the subsequent locating of the grade stakes and sometimes have recorded upon them data concerning the ditch as it is to be dug at their respective grade stakes.

LATERALS.

If the drain thus located should be the main drain of a system, the several laterals will be located in the same manner as the main was located, excepting that instead of starting from the outlet of the system each is begun at the proper point along the main.

If a system like that illustrated in Fig. 2 or in Fig. 3 is to be used no two laterals from opposite sides should be connected with the main at the same point and it is most common to place the laterals as shown in the figure, the laterals from one side connecting with the main midway between the points of connection of the laterals of the opposite side.

If the laterals are to be placed one hundred feet apart then the opposite laterals will connect at alternate stakes, when these stakes are set 50 feet apart. If the laterals are placed more than one hundred feet apart or less than one hundred feet apart it would simplify matters to drive the stakes locating the main at intervals other than fifty feet. If laterals were to be sixty feet apart then the stakes on the main should be driven thirty feet apart. If the laterals were to be eighty feet apart the stakes on the main should be driven forty feet apart. If the laterals were to be located one hundred twenty feet apart then the stakes on the main should be driven sixty feet apart, and so on.

THE ANGLES OF THE LATERALS.

It is common in systems like that illustrated in Fig. 2 to locate the laterals so that their upper angle to the main shall be less than 90 degrees. If, however, it should be deemed advisable to run the laterals at right angles to the main as shown in Fig. 3, then they should be turned slightly so as to enter the main at an angle of less than 90 degrees, the reason being that if the water from the lateral be discharged into a main at an angle of 90 degrees it is likely to interfere with the movement of the water in the main and also to interfere with the ready movement of the silt which may be carried by the waters of the main.

THE LOCATION OF THE UPPER END OF MAINS AND LATERALS.

It is not necessary to carry the end of either main or lateral to the very edge of the area to be drained. The water in the soil will move as far and as readily toward the end of the drain as it will laterally toward any other point of the drain. The line of equal influence of the drain at its end is the arc of a circle whose center is the end of the drain.

HAULING AND DISTRIBUTING THE TILE.

By this time, the kind, size and amount of tile required for the work will have been determined and purchased. The tile should now be hauled upon the field and distributed close to where the ditches are to be dug. The hauling and distributing should be done before the leveling is done,

(1) because of the danger of disturbing the grade stakes (and these stakes must not be disturbed from the time the leveling is done till after the digging of the ditch is begun) and (2) because it is not so convenient to haul and distribute the tile after the digging of the ditches has begun.

LEVELING.

The work of leveling begins with the main, if there be a system of drains to install. If there be only one drain the work of leveling will proceed in the same manner.

The object of the leveling is to determine the elevation above datum of the surface of the field at each stake along the proposed drain. The reasons for this will appear later.

The manner of leveling will be the same as that described under the use of the level, page 15.

The work of leveling will begin at the stake driven at or nearest to the proposed outlet. This stake is numbered 1.

(a) If the level to be used is a high-class instrument and the drain is not over 50 rods long, the instrument may be set up at about the middle of the length of the drain. The elevation of stake 1 will be assumed to be 10 feet above datum, and recorded as such in the proper column after stake 1 in your notes.

The first reading will be a back-sight taken at stake one. This reading will be recorded in the proper column, after stake 2 in your notes.

This back-sight reading added to the recorded height of stake 1 gives the height of the instrument.

Now take a reading on every other stake along the proposed drain. These readings will all be fore-sight readings and each will be recorded in your notes after the number of the stake at which it was taken.

Each of these fore-sight readings subtracted from the height of the instrument gives the elevation of the stake at which the reading was taken.

Note: Observe the cautions suggested on page 17.

(b) If the level used is not a high class instrument, then it should be set a little to one side of the proposed drain and about equidistant from stakes 1 and 2. As above, the elevation of stake one is assumed to be 10 ft. above datum and is recorded in the proper column after stake one in your notes.

Take a back-sight reading with the rod on stake 1, and record the reading in the proper column after stake 2 in your notes. This reading added to the height of stake 1 will give height of instrument.

Take a fore-sight reading with the rod on stake 2 and record the reading in the proper column after stake 2 in your notes. This reading subtracted from the height of instrument will give elevation of stake 2.

In like manner set the instrument in a similar position between stakes 2 and 3. Take a back-sight reading at stake 2 and a fore-sight reading at 3. The back-sight reading added to the elevation of stake 2 will give the height of instrument in the new position and subtracting the new fore-sight from this new height of instrument will give the elevation of stake 3.

Proceed in this way, taking a back-sight and a fore-sight reading be-

tween each two stakes, till the front-sight reading is taken on the last stake.

Caution: Be careful always before recording a reading to examine the instrument to see that it is perfectly adjusted.

KEEPING NOTES.

A more extensive form must be employed now for keeping records of readings, etc., than was shown on page 18. A table like the following is suggested:

TABLE III.

No. of Stake.	Distance.	Back-sight.	Height of Instrument.	Fore-sight.	Elevation.	Fall.	Elevation of bottom of ditch.	Depth of ditch.	Height of line.
1	....	....	....	....	....	....	....	....	....
2	....	....	....	....	....	....	....	....	....
3	....	....	....	....	....	....	....	....	....
4	....	....	....	....	....	....	....	....	....

In column one are recorded the stake numbers in order.

In column two is recorded the distance of each stake from stake 1.

With these distances the distance between any two stakes may be found.

As the work of leveling progresses, the back-sight readings should be recorded properly in column 3 and the fore-sight readings should be recorded in column 5.

Usually all readings are taken before computations are begun to determine the elevation of the several stakes. This of course includes the determination of the height of instrument at the several places at which it was set.

To make the succeeding steps more clear, let us take up a piece of actual work, with diagram and the data used in carrying it to completion.

Fig. 14 A-B represents the profile of the surface of a portion of one of the college fields in which it was necessary to place a tile drain. The distance A to B is 500 feet. In the original drawing 2 inches horizontally equaled 100 ft. while ¼-inch vertically equaled 1 ft. Using different scales for the two dimensions destroys the proportions and requires some use of the imagination. A-C represents a fall which provided a good outlet. Fig. 15 represents the same surface with grade stakes driven 50 feet apart according to directions on page 20, and numbered (1-11) Only one finder is shown in place, and that at grade stake 7.

Fig. 16 shows the level in the three positions described on page 22 (b), i. e.: 1st, between stakes 1 and 2; 2nd, between stakes 2 and 3; 3rd, between stakes 3 and 4. It shows, also, the leveling rod in the positions successively at which it would be held to obtain the three back-sight readings and three fore-sight readings spoken of above. There are also shown the directions in which the three back-sight readings were taken and the directions in which the three fore-sight readings were taken with their values. These readings will be found in columns 3 and 5 in Table IV.

Fig. 14. Profile of a portion of one of the college fields—now drained.

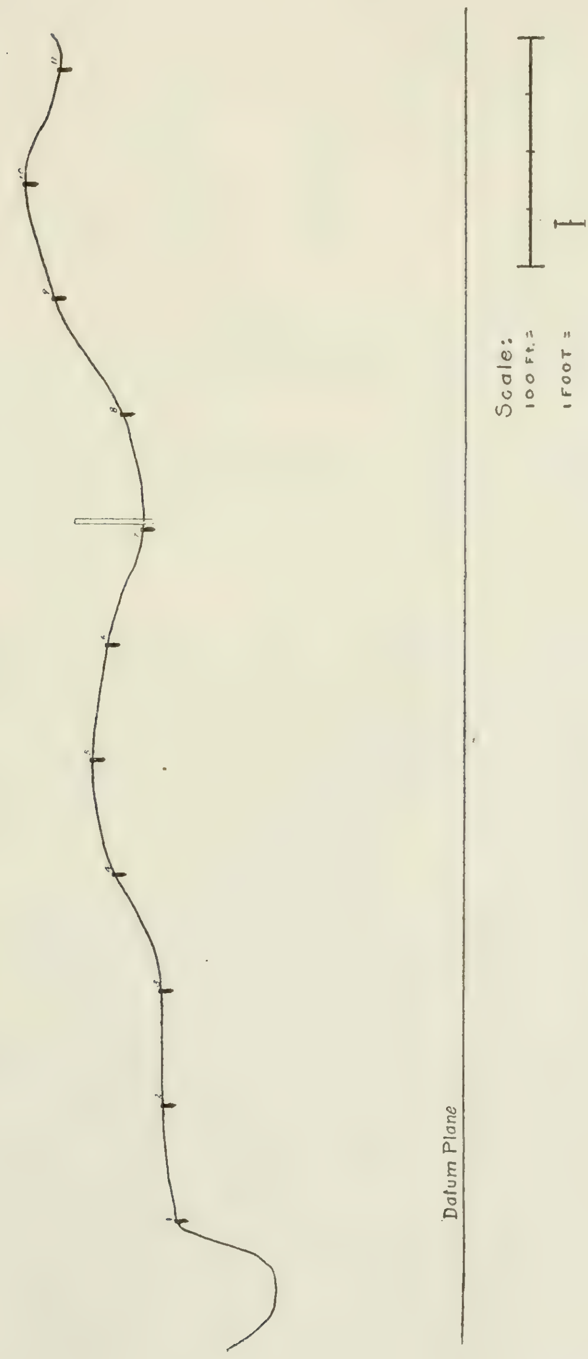


Fig. 15. Same as Fig. 14 with grade stakes and one finder in place. Datum plane indicated.

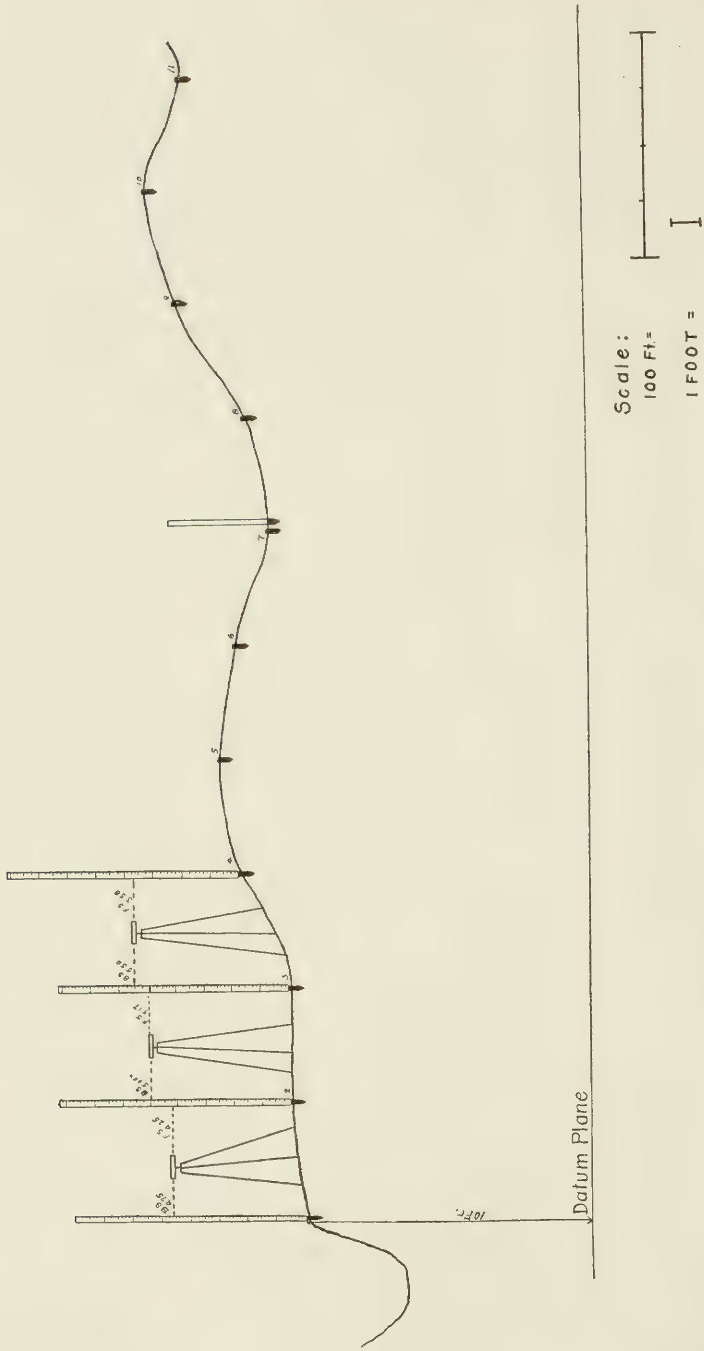


Fig. 16. Same as Fig. 15, showing level in three positions. Showing also positions of leveling rod.

TABLE IV.

No. of Stake.	Distance.	Back-sight.	Height of Instrument.	Fore-sight.	Elevation.
1..............	0	....	....	....	....
2..............	50	4.75	....	4.25	....
3..............	100	5.00	....	5.17	....
4..............	150	5.50	....	3.58	....
5..............	200	4.83	....	4.13	....
6..............	250	5.06	....	5.51	....
7..............	300	4.65	....	5.91	....
8..............	350	4.92	....	4.31	....
9..............	400	5.75	....	3.30	....
10..............	450	4.80	....	3.70	....
11..............	500	3.78	....	4.98	....

There will be found in columns 3 and 5, also, the readings taken for determining the elevations of the remaining stakes.

The leveling in this case is done with one of the cheaper kinds of grade level.

In column 1 of the table are the numbers of the stakes (1 to 11).

In column 2 is shown the distance of each stake from stake 1. In this case the stakes are located 50 ft apart, so that stake 2 is 50 ft. from stake 1, and stake 3 is 100 ft. from stake 1, and so on up to stake 11 which is 500 ft. from stake 1.

COMPUTATIONS.

With the fore-sight and back-sight readings recorded in the table, the next step is to determine the elevations of the several stakes. If the reader is sure that he understands the processes of determining the elevations he may disregard what follows in boldfaced type. If he is not sure, it is suggested that he refer to table IV, in which there is entered all the data developed to this point in the work, and that, following directions below, he determine the proper values and enter them in columns 4 and 6 of the table.

ELEVATIONS.

Observe that the back-sight reading taken at stake 1 is introduced on the line belonging to stake 2, and that in like manner each back-sight reading is introduced on the line of the stake whose elevation is sought by its use. Observe, also, that each fore-sight reading is introduced upon the line of the stake at which it was taken.

1. We assume the elevation of stake 1 to be 10 ft. above datum. This we record on line 1 in column 6. Fig. 16 shows the location of the datum plane.

2. Add the first back-sight reading, 4.75 ft., to the elevation of stake 1. This gives 14.75 ft. as the height of the instrument above datum. The height should be recorded on line 2 in column 4. Subtract the fore-sight reading, 4.25 ft., from this height of instrument. This gives 10.50 ft. as the elevation of stake 2. This elevation we record on line 2 in column 6.

3. Add the back-sight reading, 5.00 ft., to the elevation of stake 2. This gives the height of the instrument, 15.50 ft., in its second position. Record properly. Subtract from 15.50 ft. the fore-sight reading, 5.75, and we have 10.33 ft. as the elevation of stake 3. This elevation we record on line 3 in column 6.

Observe:—(1) That with each setting of the instrument one back-sight reading and one fore-sight reading were taken. (2) That adding the back-sight reading to

the elevation of the stake at which it was taken, and subtracting from this sum the fore-sight reading gives the elevation of the stake at which the fore-sight reading was taken.

Proceed in this manner until the elevations of all the stakes have been found, in each case recording the height of instrument and elevation of stake in the proper places.

At this point compare your results with those recorded in table V, below. If they do not agree in all cases go over your work to discover and correct your difficulty.

TABLE V.

No. of Stake.	Distance.	Back-sight.	Height of Instrument.	Fore-sight.	Elevation.	Fall.	Elevation of bottom of ditch.	Depth of ditch.	Height of grade bar.
1	0	....	....	....	10 ft.	....	....	....	....
2	50	4.75	14.75	4.25	10.50	....	....	....	....
3	100	5.00	15.50	5.17	10.33	....	....	....	....
4	150	5.50	15.83	3.58	12.25	....	....	....	....
5	200	4.83	17.08	4.13	12.95	....	....	....	....
6	250	5.06	18.01	5.51	12.50	....	....	....	....
7	300	4.65	17.15	5.91	11.24	....	....	....	....
8	350	4.92	16.16	4.31	11.85	....	....	....	....
9	400	5.75	17.60	3.30	14.30	....	....	....	....
10	450	4.80	19.10	3.70	15.40	....	....	....	....
11	500	3.78	19.18	4.98	14.20	....	....	....	....

FALL AND DEPTH OF DITCH.

To help in determining the fall and depth of ditch, a diagram or profile such as is shown in Fig. 17 is very helpful.

Table V is complete up to and including the elevations of the stakes, and is identical with table IV as you have completed it if you have cared to make the computations as directed in boldface type above.

In making the computations which remain we shall use Table V, and into it introduce the results which we obtain from these computations.

Two precautions are to be observed in this part of the work:

(1) Not to have the ditch unnecessarily deep at any one or more points. Unnecessary depth means added expense in digging and filling.

(2) To have the ditch sufficiently deep. Insufficient depth would endanger the tile from frost or even from plow points and it might fail to lower the ground water sufficiently for best results.

A good way to proceed is something as follows:

1. Referring to Fig. 17, we find that conditions will permit a depth of three feet at stake 1, which is practically the outlet. Three feet is a satisfactory depth. Let us establish on our diagram, Fig. 17, point a, three feet below the top stake 1.

2. For trial let us establish a point, b, three feet below the top of stake 11.

3. If the fall in our ditch is to be constant from point b to point a, a straight line connecting the two points will indicate the bottom of the ditch. We draw such a line.

It is very evident, as one looks at the diagram after drawing the line a b that this plan brings the drain very close to the surface at stakes 7 and 8. If one applies the scale, the depth is found to be not over 18 inches, and while drains are sometimes laid as shallow as this, a

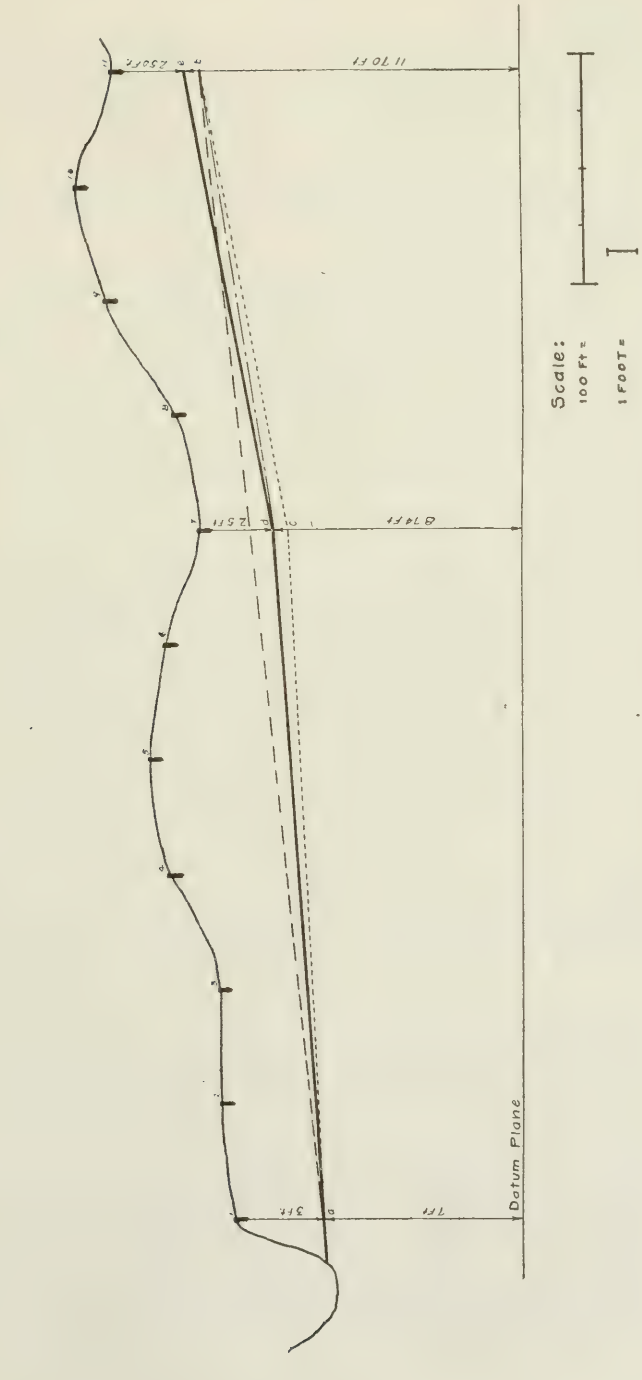


Fig. 17. Diagram used to determine fall and depth of ditch.

greater depth is preferred. This drain would be only 27 inches deep at stake 3.

4. Let us establish a point c, three-feet below the top of stake 7, and draw a dotted line from a to c, and from c to b. We have now indicated the bottom of a drain that is little less than 3 feet deep at any point. But it is over 5 feet deep at stake 5, and nearly 5 feet deep at stake 9, and these conditions, in the opinions of some persons, would call for a compromise.

5. Let us establish a new point d, 2½ ft. below the top of stake 7, and draw a broken line from a to d and from d to b. This improves matters generally from stake 1 to 7.

6. Let us finally establish a point e, 2½ ft. below the top of stake 11 and draw a new line from d to e, to represent the bottom of the drain from stake 7 to stake 11. This materially lessens the depth of digging at stakes 9 and 10.

*7. Let us adopt the line a d e, as the bottom of drain.

Observe: That the drain will be 3 ft. deep at stake 1, 2½ ft. deep at stake 7, and 2½ ft. deep at stake 11. These depths we have established for convenience and economy in the work of digging.

8. Introduce these depths in column 9 of the table—3 ft. on line 1, 2.5 ft. on line 7, and 2.5 feet on line 11.

9. If the ditch is three feet deep at stake 1, the bottom of the ditch is 3 feet below the top of stake 1, or it is 3 feet lower than stake 1. If then we subtract the depth of the ditch, 3 feet, from the elevation of the top of the stake we have 7 feet as the elevation of the bottom of the ditch at stake 1, above datum. Subtracting the depth of ditch, 2.5 ft. at stake 7 from the elevation of 7, gives 8.74 ft. as the elevation of the bottom of the ditch at stake 7. Subtracting the depth of ditch at 11 from elevation of 11, gives 11.70 feet as the elevation of the bottom of the ditch at that point.

10. Introduce these ditch bottom elevations into column 8 of Table V on their proper lines,—7 ft. on line 1, 8.74 feet on line 7, and 11.70 on line 11.

11. Before we can go farther in finding values for columns 8 and 9, we must determine the fall of the drain.

(a) The elevation of the bottom of ditch at stake 11 is 11.70 ft.
The elevation of the bottom of ditch at stake 7 is 8.74 ft.

The fall of the drain from stake 11 to stake 7 is 2.96
The distance from stake 11 to stake 7 is (500 ft.—300 ft.) = 200 ft.
The fall per 100 ft. of this distance is (2.96 ft. ÷ 2), = 1.48.

Notice the manner in which this fall is introduced in Table VI, page 31.

The stakes along this drain are 50 feet apart so that the fall from one stake to another is one-half of 1.48 ft. or .74 ft. In other words the bottom of the ditch at stake 10 will be .74 feet lower than at stake 11 and .74 ft. lower at stake 9 than at stake 10 and so on.

*NOTE.—If this drain is to be a main drain as we are planning it may be necessary because of the laterals to make the line acb, the bottom of the drain. If, however, this drain were to be a lateral instead of a main the line ade, would be better for the bottom of the drain.

11.70 feet, = elevation of bottom ditch at 11.
.74
———
10.96 feet, = elevation of bottom of ditch at 10.
.74
———
10.22 feet, = elevation of bottom of ditch at 9.
.74
———
9.48 feet, = elevation of bottom of ditch at 8.
.74
———
8.74 feet, = elevation of bottom of ditch at 7.

Showing that our subtractions are correct; for 8.74 is the elevation of bottom of ditch already in your table.

Introduce the elevations of ditch bottoms at stakes 8, 9 and 10 in column 8 of Table V.

(b) The elevation of bottom of ditch at stake 7 = 8.74 feet.
The elevation of bottom of ditch at stake 1 = 7.00 feet.
———
The fall from stake 7 to stake 1, is ...... 1.74 feet.

Find the fall per hundred feet from stake 7 to stake 1 and record in column 7 in Table V and compare your result with that in Table VI.

Find the fall also for 50 ft. and determine the elevations of bottom of ditch at stakes 6, 5, 4, 3 and 2. Introduce these elevations into the proper places in column 8. Then compare your results in column 8 with those in column 8 of Table VI.

12. We are now ready to determine the depth of the ditch at the stakes where the depths have not yet been determined.

In column 6 of your table we have the elevations of all the stakes, while in column 8 we have the elevations of the bottom of the ditch at all the stakes. If now the elevation of the bottom of the ditch at any point be subtracted from the elevation of the stake at that point, the result will be the depth of the ditch at that point. Make the proper subtractions and enter results in column 9. Compare your results with the values recorded in column 9 of Table VI.

TABLE VI.

No. of Stake.	Distance.	Back-sight.	Height of Instrument.	Fore-sight	Elevation.	Fall.	Elevation of bottom of ditch.	Depth of ditch.	Height of grade bar.
1............	0	....	....	....	10 ft.	.58 ft. per 100.	7.	3.	2.5
2............	50	4.75	14.75	4.25	10.50		7.29	3.21	2.29
3............	100	5.00	15.50	5.17	10.33		7.58	2.75	2.75
4............	150	5.50	15.83	3.58	12.25		7.87	4.38	1.12
5............	200	4.83	17.08	4.13	12.95		8.16	4.79	.71
6............	250	5.06	18.01	5.51	12.50		8.45	4.05	1.45
7............	300	4.65	17.15	5.91	11.24	....	8.74	2.5	3.00
8............	350	4.92	16.16	4.31	11.85	1.48 ft. per 100.	9.48	2.37	3.13
9............	400	5.75	17.60	3.30	14.30		10.22	4.08	1.42
10............	450	4.80	19.10	3.70	15.40		10.96	4.44	1.06
11............	500	3.78	19.18	4.98	14.20		11.70	2.5	3.00

DIGGING THE DITCH.—TOOLS.

We are now ready to begin the digging of the ditch.

Three tools especially made for tile ditching, are the ditching spade, tile scoop, tile hook.

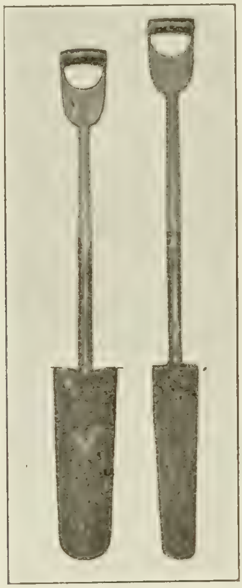


Fig. 18. Ditching spades.

The ditching spade, Fig. 18, is made in different sizes for different kinds of soil. In general the blade is long and narrow, partly to lesson the number of spade depths or cuts necessary to dig the ditch and partly that the spade full of soil is less likely to slip from the blade in lifting the soil to the surface.

The tile scoop, Fig. 19a and Fig. 19b, is used in shaping the bottom of the ditch to receive the tile. It is made in different sizes, to correspond more or less closely to the size of tile to be laid.

The tile hook is used to lift and properly set the tile in place. It is used chiefly when the operator works from the surface of the ground. It consists of a long wooden handle, carrying a rectangular hook of ½-inch round iron 10 inches long. Fig. 20.

It is desirable also to have a common spade, a common long handle shovel, and sometimes a pick, especially when a heavy clay sub-soil is likely to be encountered.

OTHER MATERIALS.

It will be necessary also to have a few hundred feet of strong, light cord, a few light, sharp stakes 2 feet in length, and material to be used in setting grade bars.

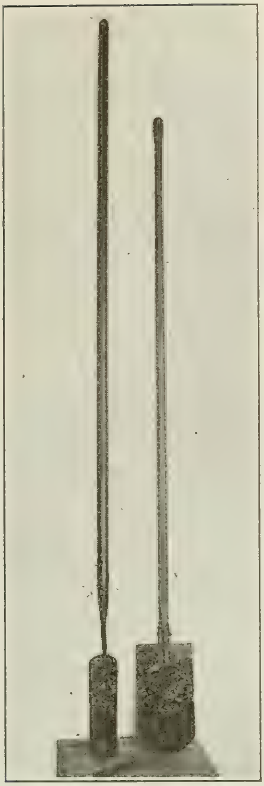


Fig. 19a. Tile scoop.

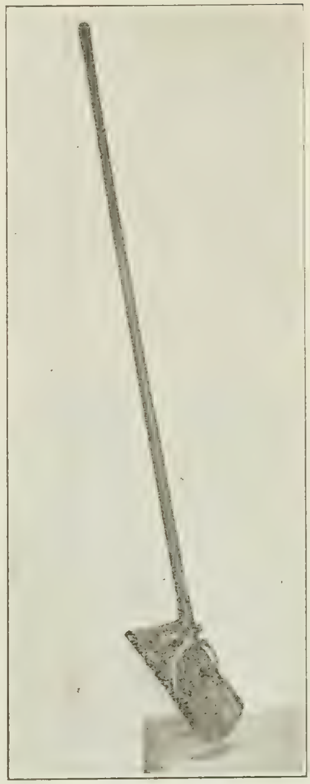


Fig. 19b. Tile scoop.

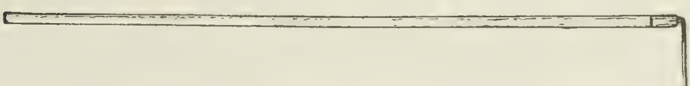


Fig. 20. Tile hook.

GRADE BARS.

We have determined how deep the ditch must be dug at each grade stake. It is necessary to provide some simple means (1) by which we may know just how deep to dig at every point, and (2) by which we may scoop out the bottom of the ditch so that the fall shall be constant from one grade stake to the next above or below. In Figs. 21 and 22 are shown what are known as grade bars. These grade bars are set up over each grade stake, and the top of every grade bar is set at the same height above the proposed *bottom of the ditch*, and horizontal. This height is usually 5.5 ft. in our own practice. Some persons prefer to make it 6 ft.

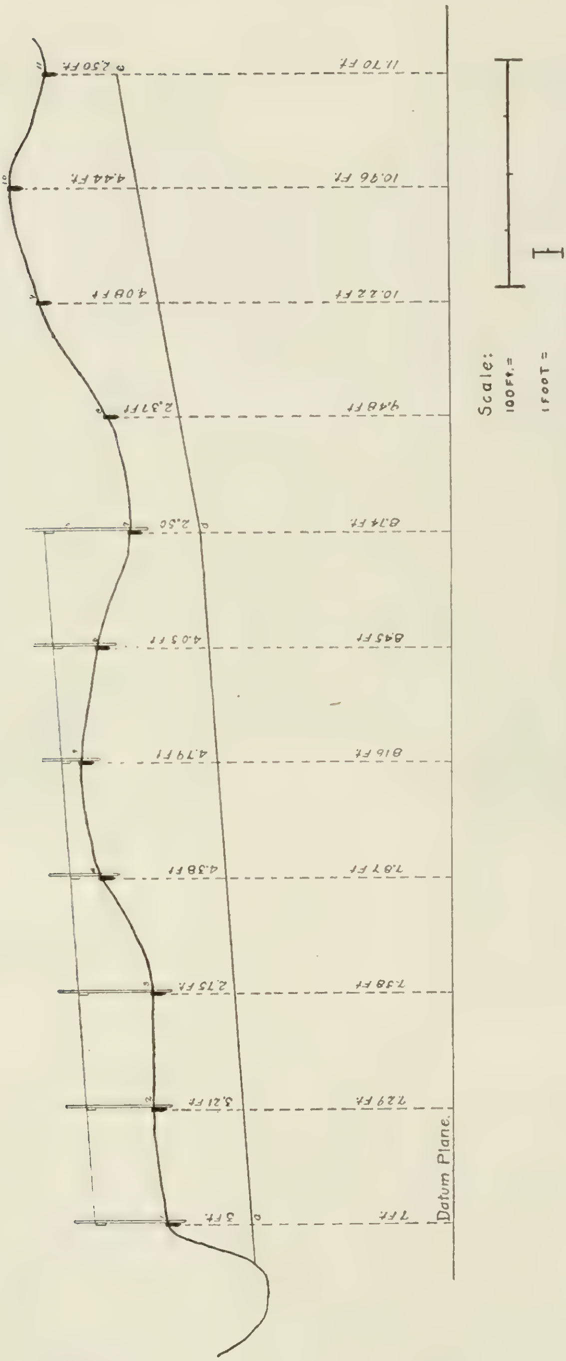


Fig. 21. Grade bars located in this case five and one half feet above the proposed bottom of the ditch. a d e represents the proposed bottom of ditch as shown in Fig. 17.

A light strong cord drawn tight and resting on the tops of these grade bars will stand parallel to the proposed bottom of the ditch. If then, the cord extends above the center of the ditch, and 5.5 feet above the desired line of bottom, the workman finishing the bottom can, with a light rod bearing a 5.5 ft. mark, by placing the rod on the bottom of the ditch at any point and holding the top of the rod against the line, tell when he has brought the bottom to the proper depth.

HEIGHT OF GRADE BAR.

The height of the grade bar above any stake is found by subtracting the depth of the ditch at that stake from the height the line is to stand above the bottom of the ditch (5.5 ft. in our practice.)

Turn again to Table V and determine the height of the grade-bar at each stake. This will be found in each case by subtracting the depth

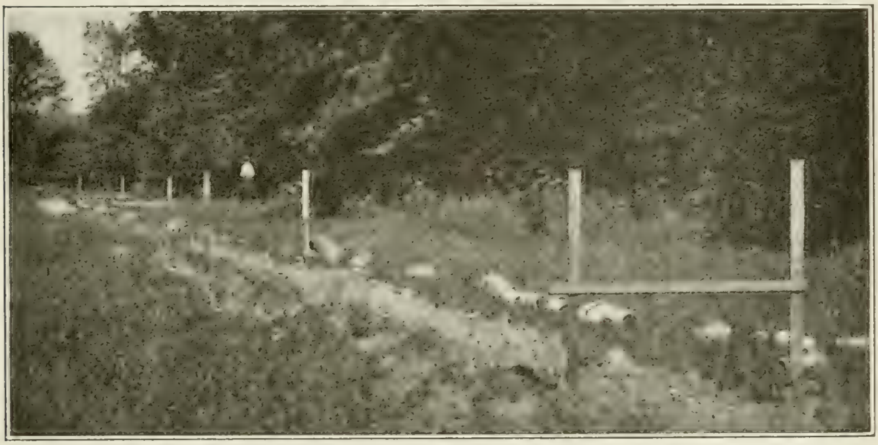


Fig. 22. Grade bars.

of the ditch as recorded in your column 9 from 5.5 ft. Record your results properly in your column 10 and compare your results with those in column 10 of Table VI.

THE WORK.

1. The grade bars should be put up. This is sometimes put off till after the digging is well under way. The objection to this plan is that the grade stakes are likely to be disturbed by the workmen when the digging begins.

The grade bar should be 4 to 6 ft. long, usually ⅞-inch stuff with one straight edge. With each bar there must be two stakes preferably ⅞-inch x 4-inch to 6-inch and sufficiently long to stand higher, when they are driven into the ground, then the height of the bar at that stake. The two stakes should be driven firmly into the ground one on each side of and out about one foot from the ditch and so that the two stakes and the grade stake shall stand in a straight line, at right angles to the ditch.

When the stakes are in place, a leveling rod should be set upon the grade stake, and the grade bar, straight edge up, should be placed against the stakes and with its upper edge at the proper height as measured upon the rod. By the use of a spirit level laid upon the upper edge of the bar, the bar is brought to the horizontal and held firmly against the stakes and nailed in place. See Fig. 23. The proper height of each bar above its grade stake is found in column 10 of your table.

When the bars of the first section of the drain are up, the upper edges should lie in the same plane as you sight over them. If the upper edge of any bar does not lie in this plane, you have made a mistake somewhere either in your computations or in your work. Find your mistake and correct.

The line need not be stretched over the bars until the work of digging has been started.

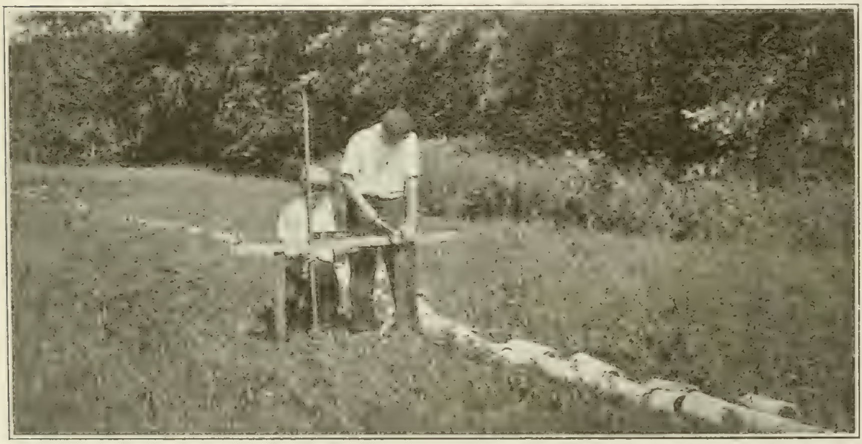


Fig. 23. Nailing a grade bar in place.

2. The work of digging should begin at the outlet and should proceed toward the upper end.

(a) A line should be stretched about one inch in from the grade stakes to mark the edge of the ditch, and along this line the surface should be cut three inches deep, with a sharp spade. The chief object of the line is to insure a straight edge for the ditch. This edge should be carefully worked to.

Usually it is not necessary except with beginners to stretch a line to locate the other edge of the ditch. The spade should be used to establish it by cutting about three inches into the surface.

(b) Care should be exercised not to open the ditch too wide. The professional ditch digger seldom opens a three-foot ditch more than 10 to 11 inches wide. The wider the ditch the more dirt must be handled.

(c) With the edges of the ditch established, the removal of the top soil begins, and in this work a common spade or shovel is usually used, for one cut deep. Several rods of ditch may be opened up in this way.

(d) The next cut is made with the ditching spade following the first cut its entire length.

In like manner a second cut will be made and as many more as may be necessary (using the ditching spade) to bring the ditch to within a few inches of the bottom. It is usually best to throw all of the dirt to one side of the ditch.

(e) Before beginning the last cut, the line should be tightly stretched over the tops of the bars and just over the straight edge of the ditch and the rod brought into use to guard against getting the ditch too deep, at any point. If in stretching the line the ends are tied to the end grade-bars, braces should be placed against the stakes; otherwise the bars and their stakes will be drawn out of place. A good way is to drive a stake into the ground beyond the end bar, wrap the line once around the grade bar and then tie to the stake just driven.

(f) After any cut, if for any reason a considerable amount of loose dirt lies in the ditch it should be removed by the use of the long-handle shovel before the next cut is begun, or, if the last cut has been made, before starting to use the tile-scoop.

(g) When the ditch has been dug to within two inches of the bottom as above described, the line above the bars is carefully moved out over the center of the ditch and tightened. Then with the tile scoop, a trough or hollow is dug along the center of the ditch and finished so that at all points it shall measure just 5.5 ft. below the line. This requires careful work and frequent use of rod bearing the 5.5 ft. mark previously mentioned.

If at any point too much earth is removed and the ditch made too deep thereby, a sufficient amount must be returned and carefully moulded into place with the scoop to bring the bottom up to grade. The less the fall the greater is the care that must be exercised in finishing the bottom. This part of the work is not difficult. It does require care. It is sometimes done from the surface. Usually, however, the workman stands in the ditch.

LAYING THE TILE.

The laying of the tile should begin at the outlet and proceed toward the upper end.

It is usually best to lay the sections of tile as rapidly as the bottom of the ditch is made ready with the tile-scoop to receive them.

Some workmen lay the tile by hand and some use the tile hook. Some workmen stand upon the surface to finish the bottom of the ditch and to lay the tile.

It will be found that the ends of the tile are frequently not square,—are not at right angles to the sides of the tile. It will be found that the tile is sometimes warped, or bowed, thus throwing the ends out of square. There are likely to be little inequalities in the bottom of the ditch. Because of these three facts, it will be found that if a lot of tile be laid, promiscuously, end to end in the hollow at the bottom of the ditch, many of the joints will be so open that sand will very readily drop through into the tile drain, so that if the tile were left in this position and the ditch filled, the drain would be clogged in a very short time. There should be no open joints.

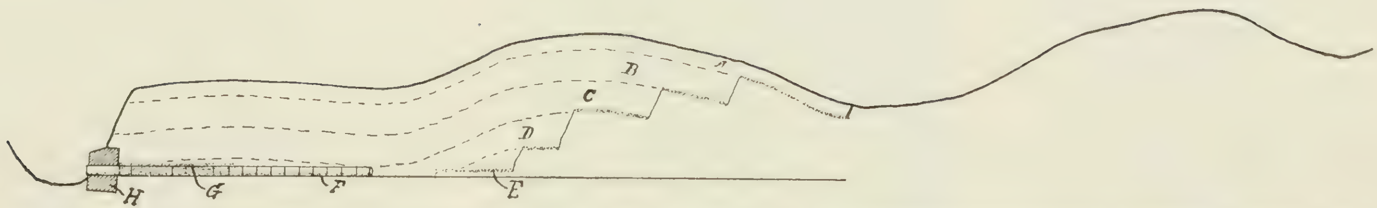


Fig. 24. Showing steps in digging ditch:—A top section removed with shovel; B, C, D sections removed with ditching spades; E place where the tile scoop is used; F tile in place; G earth holding tile in place; H outlet.

If when a section of tile is laid into place, it does not fit tightly against that already laid, it is usually found that by rolling it to the right or left, it can be made to fit so tightly as to practically prevent the passage of soil particles except quick-sand or fine silt. Sometimes this cannot be done and a new piece of tile must be substituted. A piece that cannot be made to fit in one place will frequently readily fit in another place in the same line of tile.

As the work of laying the tile progresses the workman should shovel in upon the tile a sufficient amount of loose soil to settle down about the sides and partly or wholly cover the tile. This holds the tile in place until the filling can begin. Sometimes, instead of shoveling in soil from the surface some soil is loosened from the walls of the ditch to fall upon the tile and accomplish the same results. This covering of the tile is called blinding.

When the last tile of any drain is laid, a stone or piece of brick or pieces of broken tile should be laid against the upper end and soil shoveled against it to hold it in place. This keeps the soil from working into the end of the tile.

FILLING THE DITCH.

The filling may proceed as rapidly as the tile are laid and anchored. Sometimes it is done by hand. Sometimes it is hastened by the use of a plow or a scraper. When a plow is used an evener must be provided that is sufficiently long to allow the horses to walk on opposite sides of the ditch. When the plow is used, the bars and stakes must first be removed. The team is driven the length of the ditch or for a considerable part of it at a time and the soil is plowed back into the ditch. The plow is run back empty.

Only the board scraper is convenient for filling. The team works on one side of the ditch and the man and scraper on the other. A chain or rope must be used between the team and scraper and it must be sufficiently long so that the team will not be backed sufficiently near the ditch to result in accident.

When plow or scraper is used it is usually necessary for a workman with a shovel to finish the work.

FINISHING THE OUTLET.

The outlet of the main drain, should be completed with two things in view:

1. To provide against its destruction by frost, flood, tramping of live stock, etc.

Usually it is best to replace the lower six or eight feet of tile with glazed sewer pipe or sometimes with a piece of iron pipe of proper size. This should be done of course when the work of laying tile begins.

To prevent the washing or tramping away of the earth about the outlet and to give strength, a wall of masonry or cement should be built something as shown in Fig. 24.

2. Means should be provided to prevent vermin, such as rats, etc., from entering the mouth of the drain. To accomplish this a screen of woven wire or a grate of iron bars mounted on or in a strong wooden frame should be firmly set against the outlet. See Fig. 25.

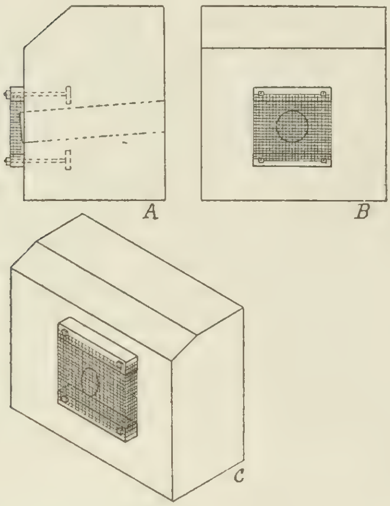


Fig. 25. Illustrating screen of woven wire to protect outlet of tile.

It would be well in building the cement work to set in bolts to hold the screen in place as shown in Fig. 25A.

JOINING LATERALS TO MAINS.

Mention has already been made of the angle at which the lateral should be brought to the main.

Two general methods of making connection are suggested.

1. By the first method the lateral discharges into the side of the main.

In this case the center of the lateral should come even with the center of the main. This means that if the lateral tile has a smaller diameter than the main tile, the bottom of the lateral ditch must be planned to approach the main ditch higher than the bottom of the main ditch by one-half the difference of the diameters of the main and lateral tiles.

To make connection, a hole should be picked in the wall of the main at the proper point, and this hole should be made as large as the outside diameter of the lateral tile. The end of the lateral tile should be rounded back at the sides so that the end when the tile is in place shall stand in flush with the inner wall of the main. When the lateral thus fitted is put into place fragments of broken tile should be carefully laid in over the joint, and earth packed in about it.

2. By the second method the lateral discharges its water down through the top of the main tile.

In this case an opening is made through the top of the main and through the bottom of the lateral.

In digging the lateral ditch the bottom should stand sufficiently above the bottom of the main ditch so that the center of the lateral tile shall stand even with the top of the main tile. The end of the lateral tile should project well over the main and should be plugged with a stone or with cement. The same precautions should be taken as in 1 above

to close the joint sufficiently to prevent the soil from working through the tile.

MAKING OPENINGS THROUGH TILE.

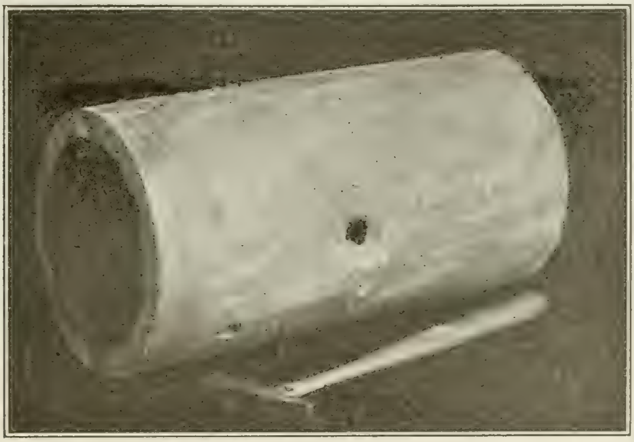


Fig. 26. Five inch tile with small opening, and hammer used in making the opening.

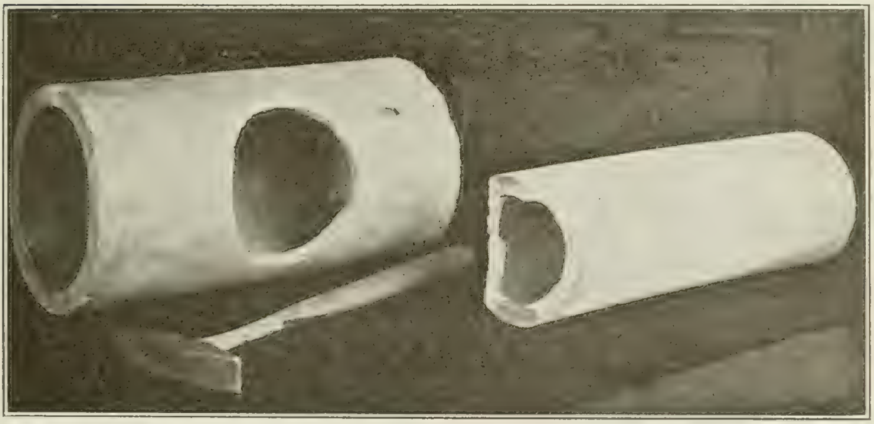


Fig. 27. Five inch tile shown in Fig. 26 with opening enlarged to receive three inch tile. The three inch tile is shown with end shaped to set in the opening in the larger tile. The larger hammer used is also shown.

An opening through the wall of a section of tile is easiest made with what is called a tile pick. With care the opening can be made with a small headed hammer by first knocking a small opening in the wall about where the center of the opening should be and then carefully chipping away the edges of the opening until it is made sufficiently large. With the smaller sizes of tile, the section should be held in one hand while the opening is being made with the hammer in the other hand. See Figs. 26, 27 and 28.

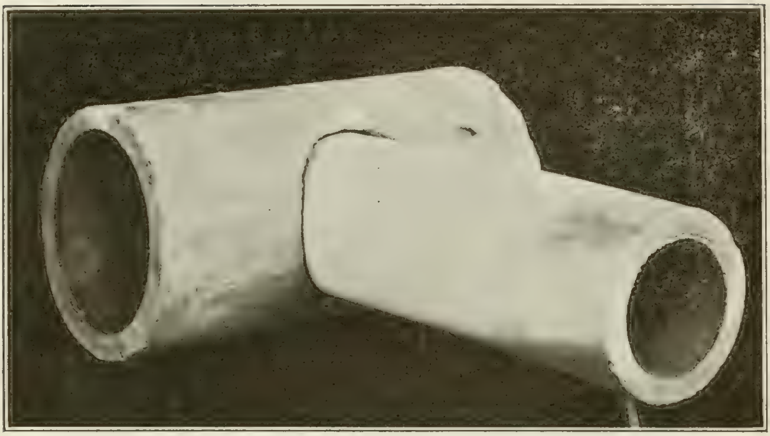


Fig. 28. Shows the connection when tile are fitted and in place.

DESIGNATING THE SUB-MAINS AND LATERALS AND NUMBERING THEIR GRADE STAKES.

In keeping the field notes it is desirable to have some definite method of designating the mains, sub-mains and several laterals. The main is usually designated simply as main while the sub-mains and laterals are designated by a name or symbol which indicates the particular stake in the main or sub-main at which they discharge their water. A sub-main discharging its water at a point where the grade stake upon the main was No. 7 for example, would be designated $\frac{\text{Sub-M}}{7}$ and the grade stakes along that sub-main would be designated $\frac{\text{Sub-M}}{7}$ 1, 2, 3, &c. A lateral connecting with a main at grade stake 10 would be designated Lateral 10—and its grade stakes would be designated as Lateral 10-1, 2, 3, &c, or Lat. 10/1, 2, 3, &c. A lateral connected at grade stake 6 on sub-main 7, would be designated as $\frac{\text{Sub-M 7}}{6}$ and its grade stakes would be designated as $\frac{\text{Sub-M 7}}{6}$ 1, 2, 3, &c. and would appear in column one in the note as

Stake.		Dist.	B. S.	H. I.
$\frac{\text{Suo-M 7}}{6}$	1.			
	2.			
	3.			

The elevation of the ditch or any sub-main or lateral should be such that the center of its tile shall center with the tile into which it dis-

charges, or such that the bottom of the tile shall rest properly upon the tile to which it discharges according to which of the methods of connection is used.

MISCELLANEOUS SUGGESTIONS.—UNDERGROUND OUTLETS.

It sometimes happens that a low area requires draining but has no outlet through which the water can be drained. Not infrequently it will be found that the soil of this low area is underlaid with a heavy clay and that the clay in turn is underlaid with an open gravel or an open gravelly sand, in which the water table stands at a considerable distance below the clay. Under such conditions, if a well three feet in diameter be dug through the clay into the gravel, all of the water from this low area may be drained into this well and the water will disappear down through the gravel. The well should be dug to a depth of a few feet below the clay and should be filled with field stone to above the point where the outlet of the drain is turned into it. The top stones should be small and upon these should be placed gravel, then sand, then the regular soil of the field. The writer has in mind one such arrangement in which a tile system covering something like 160 acres discharges its water and has been in successful operation for many years.

In small depressions such a well at the lowest point is frequently sufficient to carry away the excess of water without the aid of a tile system.

QUICK-SAND.

It sometimes happens that quick-sand is encountered at or near the bottom of the ditch in laying the tile. In such case it will usually be

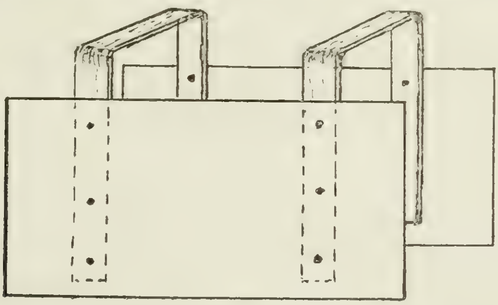


Fig. 29. Steel shield used to hold back quicksand. Should be 28 inches long and 12 inches or more high.

necessary to use some kind of guard to hold back the quick-sand while the bottom of the ditch is being completed, to receive the tile. Fig. 29 shows a shield of iron used for this purpose. In the use of the shield the ditch is dug to the quick-sand. The shield is then placed so as to include that portion of the ditch in which the next section or sections of tile are to be laid. The workman can press it down into the quick-sand by his own weight sufficiently to bring it even with or a little below the bottom of the ditch when it is complete, or if his weight is not sufficient for that, he may remove a portion of the sand inside the shield and

then place his weight upon the shield and lower it little by little to the bottom of the ditch. Then with a tile scoop the bottom of the ditch can be properly formed and the tile laid in place. The shield is then lifted and moved ahead sufficiently to prepare the bottom for the next section. It would not be difficult to make a shield of wood that could be operated in much the same way.

Where the ditch is deep and the quick-sand is found to stand to some height above the bottom of the ditch, planks or boards should be used to hold the banks from falling in and great care should be taken to avoid accidents.

PROTECTION TO JOINTS AGAINST QUICK-SAND.

When tile is laid in quick-sand or in very fine ordinary sand or silt, it is usually necessary to provide some means to prevent the fine particles from entering into the tile through the joints. It is sometimes recommended that marsh hay be laid over the tile before any soil is introduced into the ditch.

Strips of strong building paper are sometimes laid over the joints before the earth is introduced.

A small amount of clay is sometimes placed over each joint before the earth is thrown over the tile.

BOGGY AND SPRINGY PLACES.

Sometimes in laying tile through muck soils, springs are discovered which cause such a degree of softness in the muck at the bottom of the ditch that it is very difficult to lay the tile with any degree of evenness. In such cases it is recommended by successful drainage engineers that the ditch be dug sufficiently deep to lay a six-inch board in the bottom so that the upper surface of the board shall lie at the proper depth and upon this the tile be laid and the earth introduced about the tile. Boards thus used will resist decay for many years.

THE COST OF TILING.

The cost of tile, and the cost of hauling and distributing the tile are matters that can be fairly easily determined for any particular job.

The cost of digging the ditch, laying the tile, and filling the ditch is subject to considerable variation, due to the nature of the soil and the cost of labor.

Elliot estimates that where:

1. The earth is readily spaded and no pick or bar is required in the digging, and
2. The wages for good diggers is 25 cents an hour and for expert ditchers is 35 cents an hour, (the last representing half the labor required and including superintendence).

The cost of digging the ditch, laying the tile and blinding will approximate the figures shown in the following table.

Approximate cost per rod of digging ditch, laying tile, and blinding under conditions named above.

Depth of ditch.	For 4-inch, 5-inch or 6-inch tile.	For 8-inch tile.	For 10-inch tile.
2 feet	25 cents	34 cents	42 cents
2½ "	28 "	28 "	47 "
3 "	32 "	42½ "	53 "
3½ "	35 "	48 "	60 "
4 "	40 "	54½ "	68 "
4½ "	45½ "	62 "	77 "
5 "	52 "	70 "	87 "

Where the ground is so hard as to require a considerable use of the pick or bar the cost may reach double that indicated in the table.

The filling of a three-foot ditch will cost three cents per rod where a team and plow or scraper are used, or six cents per rod when done by hand labor. The cost of filling other sizes of ditch will vary from these figures according to the depth and width of the ditch, and will be about proportional to the cross section of the ditch.

In Lenawee County, Mich., a common practice is to charge by the foot for digging the ditch and laying the tile. When the drains average 3 ft. deep the price is 1½ cents per foot for laying different sizes up to and including 4-inch tile, while the price is 2 cents per foot for 5 and 6-inch tile. Above 6-inch tile, wages are usually paid by the day.

—J. A. JEFFERY.

GENERAL TREATMENT FOR APPLE ORCHARDS.

Special Bulletin No. 57.

In the winter or early spring, inspect the trees for San Jose, scurfy or oyster-shell scale. (Send twigs and strips of bark to the Experiment Station, if you cannot identify the scale yourself.)

These scales, especially the San Jose scale, must be destroyed promptly or they will kill the trees.

Just Before the Buds Open, if the scale be present, spray with the *strong* lime-sulphur wash. To be successful, the work must be done very thoroughly—this means that *every part* of the tree must be covered with the spray.

Just Before the Blossoms Open, or When They Are "In the Pink," a spraying must be made to prevent scab and other fungus disease and the canker-worm, bud-moth and a few other insects. For this and the sprayings that follow, use the dilute lime-sulphur or the Bordeaux mixture. To every fifty gallons, add two or three lbs. of arsenate of lead. (With lime-sulphur, this is the only poison that can be used.)

After the Blossoms Fall and the Stamens Wither, and before the calyx closes, another spraying must be made just like the one before. At this time direct the spray downward from above as much as possible, and with the highest pressure available, the object being to get some of the material into the calyx cups, to poison the codling moth when it appears and attempts to enter.

Cut open a calyx cup occasionally, if the spray has not been driven inside you are not doing a thorough job.

This is a very necessary spraying. If well done it usually means a good crop free from worms.

About Two Weeks After the Above Spraying, make another. Use same mixture and poison as in previous spraying.

Late In July or Early In August, there will be a second generation of codling-moths. Just when this will occur for your locality can be determined. (See "When the codling-moth flies" page 177.)

Protect fall and winter varieties against the codling-moth and a possible late outbreak of scab. Use the usual amount of poison, but the *dilute* lime-sulphur, or the Bordeaux which can be made somewhat weaker than before.

The lesser apple-worm, which works more superficially than the codling-moth, when present requires a spray of poison when standard winter varieties are from 1 to 1½ inches in diameter.

GENERAL TREATMENT FOR PEACHES.

Inspect for scale insects, the same as for apple and spray with *strong* lime-sulphur wash the same as directed for apple trees.

If this spraying is made, it will also prevent the leaf-curl disease. If the lime-sulphur spraying is not required, a spraying must be made

to prevent the leaf curl which is often especially serious on Elbertas. For this spraying, use Bordeaux mixture or the copper sulphate solution (2 pounds of copper sulphate dissolved in fifty gallons of water). It is very important that this spraying be made *before* the buds swell. If made after that time, it will not be successful in preventing the leaf curl.

If the fruit in your orchard is commonly affected with the rot and the scab (the small black specks usually on the upperside) and the curculio ("the insect that stings the fruit")—and most of the peach orchards in Michigan are affected with all of these—make sprayings as follows:

Just After the Blossoms Drop and Most of the "Shucks" Have Fallen Off, spray with poison using 2 pounds of arsenate of lead in every 50 gallons of water.

Never use any arsenical other than arsenate of lead, on peach.

Two Weeks After the Previous Spraying, another must be made. This time use the self-boiled lime-sulphur and to every 50 gallons add 2 pounds of arsenate of lead. The *dilute* lime-sulphur has not been generally satisfactory on peaches. Even when very *dilute* some burning of the foliage has resulted.

About One Month Before the Fruit Ripens, spray again and the same as directed above.

In orchards where the curculio is not present or not serious, the spraying recommended "Just after the blossoms fall" can be omitted.

Self-boiled lime-sulphur settles rapidly, so keep well agitated and do not add the arsenate of lead until just before spraying. Use fine nozzles and give the trees a uniform coating of a mist-like spray.

Peach Tree Borer. Dig out by hand early in spring or late in fall at points where gumming shows. Sterilize knife with carbolic acid to prevent spreading crown gall which may be present.

"PEACH YELLOWS" AND "LITTLE PEACH."

These two diseases are extremely contagious and very difficult to positively identify. Their causes are unknown and the only method of control is destruction of the tree—fruit, root and branch—as soon as discovered. It is especially important that diseased trees should not be allowed to blossom as it is believed the disease is spread by insects at that time. Both old and young trees of all varieties of peaches and probably all varieties of Japanese plums are susceptible to the two diseases. Both diseases may be present in a tree at the same time.

Peach Yellows. The first symptoms in a young tree, previous to bearing, are indicated by the leaves of one or two limbs turning from a rich dark green to a "yellowish green or reddish rusty green" color; this is accompanied by a rolling of the leaves from their edges. These leaves ripen and fall earlier than normal leaves. The fruit buds are larger and more mature in appearance and in the spring will invariably bloom earlier than healthy buds. In some instances, the symptoms are not confined to one or two branches, but many of the leaves in the center of the tree turn yellowish or light green, roll slightly from their edges and droop considerably. These latter symptoms are often present in cases of "Little Peach."

Upon bearing trees, there may be any one or all of the following symptoms: the fruit may ripen prematurely—one to three weeks— upon one or two branches or over the entire tree. The fruit may have numerous red spots on the surface, the spots sometimes extending in red streaks partially or wholly through the flesh to the pit. Often the flesh, about the pit, is full of radiating streaks of red. The surface of the fruit may be smooth or considerably roughened and the flesh more or less stringy and very insipid. The leaves may be yellowish pale or reddish rusty green in color, usually rolling and drooping. In advanced stages, numerous finely branched shoots bearing many slender sickly leaves. appear on the trunk or main limbs and sometimes in the extremities of the branches. *Finally the tree dies.*

Winter injury to the bark of the trunk or main limbs, mechanical injury by mice, rabbits, peach borers, cultivators, etc., or a serious lack of moisture or nitrogen in the soil may discolor the foliage and cause premature ripening of fruit and should not be mistaken for "Yellows."

LITTLE PEACH. In "Little Peach," characteristic symptoms are: the leaves of a part or the whole of the tree have a bunched appearance, and are shorter, and broader than normal leaves. They are usually yellowish-green in color with the veins appearing dilated and darker than the intervening tissue. The fruit is usually under size and ripens from a week to two weeks late. The flesh is more or less stringy, watery and very insipid while the pit is usually very small. One or all symptoms may be present and unless they can be positively attributed to some other cause, the tree should be condemned, pulled out and burned.

GENERAL TREATMENT FOR PEARS.

Inspect for scale insects and if present, spray before the buds start with *strong lime-sulphur.* The *Pear Blister Mite* (a mite that causes thickened red and brown spots on the leaves) and the *Pear Psylla* may also be partially controlled by this spraying for scale. If these pests were serious last year, make the strong lime-sulphur spraying even if not needed for the San Jose scale.

APPLY THE SAME GENERAL TREATMENT TO PEARS as is given for apples. If the *dilute* lime-sulphur is used, it should not be as strong as for apples (see dilution table on last page).

Pear Blight or Fire Blight was very serious last season in many parts of the state. It is easily noticed, a branch dies back from the tip, leaves turn brown, wither but do not drop. Is caused by a germ that works within the twig and hence spraying is not a preventative. It usually is more serious in rapidly growing trees and for this reason, many pear orchards are left in sod. Cut out the diseased twigs and branches. Make a frequent and systematic inspection of every tree and cut out every diseased twig and branch found. Cut several inches below where the wood appears to be dead. Carry the dead portion out of the orchard and bury or burn. After every cut, wipe off the wound with a cloth or sponge moistened with a 5% carbolic acid solution.

If slugs appear, spray with an arsenical, if not too near ripening of fruit to be dangerous. In case of early pears *fresh* hydrated lime may be dusted on.

GENERAL TREATMENT FOR PLUMS.

Plum trees may be infested with the San Jose and European fruit scale. The treatment for them is the same as recommended for scale on apples. (Page 1.)

Just Before the Buds Swell, spray with the *dilute* lime sulphur (or the Bordeaux mixture) and arsenate of lead, 2½ to 3 lbs. to a barrel. This is to prevent leaf-spot, fruit rot, black knot and curculio.

Arsenate of lead is preferable to Paris green on all stone fruits, owing to tenderness of foliage in such fruits.

Immediately After the Blossoms Fall, it is very essential to make another spraying using the *dilute* lime-sulphur or Bordeaux mixture or *self-boiled* lime-sulphur and two pounds of arsenate of lead to every 50 gallons. (For the Japanese varieties use the self-boiled lime-sulphur or dilute the Bordeaux one-half.) This spraying is to prevent the leaf trouble, fruit rot and curculio, be sure it is made *immediately* after blossoms fall. Our experiments last year showed that dilute lime-sulphur was very satisfactory on plums and it is easier to prepare and spray than Bordeaux or *self-boiled* lime-sulphur.

Ten Days or Two Weeks Later, it will pay to repeat the previous spraying, especially if the weather is wet or the curculio is serious. This spraying should be repeated every ten days or two weeks until there is danger of staining the fruit; stopping at least a month before picking time.

On varieties especially susceptible to rot, an application of weak copper sulphate may be made about two weeks before ripening. One pound of copper sulphate to 150-200 gallons of water. No poison need be used.

Black Knot. Early in the spring a careful inspection should be made of every tree, and *all* "black knots" cut out and destroyed. Cut back several inches below the knot. Disinfecting cuts as for pear blight is not necessary. Wild cherry trees harbor the disease and if diseased ones are near plum or cherry orchards, they should be destroyed, if possible.

GENERAL TREATMENT FOR CHERRIES.

Cherry trees may be infested with San Jose scale. If found, the treatment is the same as that recommended for the apple.

Just Before the Blossoms Open, spray with dilute lime-sulphur, self-boiled lime-sulphur or Bordeaux mixture. This is to prevent the rot and leaf spot troubles. Especially valuable on the English Morellos for the latter. Our experiments last season indicate that the dilute lime-sulphur is just as satisfactory as the Bordeaux or self-boiled lime-sulphur for cherries.

Just After the Blossoms Fall, make a spraying like the above with the addition of 2 pounds of arsenate of lead to every 50 gallons of spray solution. This spraying is directed against the rot and leaf spot, curculio and slug.

Ten Days or Two Weeks Later, it may be necessary to make another spraying like the previous one for the rot and leaf spot. The need for this spraying will depend upon the susceptibility of the variety to the rot and the weather conditions of the season.

Large Black Lice may appear on the leaves at any time. A spraying of tobacco water (see page 16) will destroy them if applied before the leaves curl too tightly.

Slugs sometimes appear after the fruit is harvested, a spraying of arsenate of lead (2 or 3 pounds in 50 gallons of water) will destroy them.

GENERAL TREATMENT FOR GRAPES.

Grape vines are not often subject to attacks by scale insects so there is seldom need for a spraying with *strong* lime-sulphur before growth starts.

Do not use the *dilute* lime-sulphur at any time for grape spraying. It stunts or checks the growth of the berries. Use the Bordeaux mixture.

Grape black-rot has become a serious disease in the grape growing regions of Michigan. Last year, it was not as serious as during several years before. But growers who left a row unsprayed last year, found enough rotten fruit to convince them that the spraying was necessary and more than paid all the expenses connected with the work.

When the Shoots Are About 8 to 10 Inches Long, spray with Bordeaux mixture for black rot.

Just Before Blooming, spray again with Bordeaux mixture for black rot and to every 50 gallons of the Bordeaux, add 2 or 3 pounds of arsenate of lead to poison the grape berry moth and the rose-chafer. If this latter is serious use stronger poison even up to 5 lbs. to 50 gallons. A pint of the cheapest molasses added may help.

Just As the Blossoms Are Falling, make another spraying like the above.

About 10 Days or Two Weeks Later, it may be necessary to make another spraying like the two previous, but this will depend upon the weather conditions and the amount of rot prevalent. If later sprayings are thought to be necessary, some material should be used that will not stain the fruit such as weak copper sulphate solution. (See page 173.)

There are several grape insects that are found only in occasional vineyards and then not every year. The grower should keep a sharp watch of his vines for them and if found, take prompt measures to destroy them. (If not familiar with their appearance send specimens to The Entomologist, East Lansing, Michigan.)

Those most likely to be found are the following:

Flea-beetles may appear at any time but are most likely to come as the buds open in early spring. Spray with Bordeaux mixture and a strong poison, 3 or 4 pounds of arsenate of lead to every fifty gallons of the Bordeaux; if early in spring. Later use less poison.

In vineyards where the grape-berry moth is serious, spray with Bordeaux and an arsenical poison during the middle of July, before the 20th.

For leaf-hoppers, sometimes incorrectly called "Thrip," spray with nicotine or with kerosene emulsion while the insects are young, and before they can fly. Later in the fall, clean up all rubbish and burn after cold weather sets in.

For climbing cut-worms, use cotton bands or bands of sticky mixture. On tender growth these can be put on strips of paper.

GENERAL TREATMENT FOR CURRANTS AND GOOSEBERRIES.

San Jose and European fruit scale are often found upon these bushes. Inspect carefully for them. If found, spray before growth starts with *strong* lime-sulphur.

Just as the Leaves are Expanding, spray with *dilute* lime-sulphur or Bordeaux and two pounds of arsenate of lead to every fifty gallons.

Repeat this spraying when the fruit is about one-fourth grown.

If worms trouble after this, use pyrethrum or hellebore.

Leaf bugs or aphids may appear. When they do, spray with nicotine or strong tobacco water while the bugs are red and wingless and before the leaves have become curled.

Gooseberry Mildew is a fungous disease that is especially troublesome on the English varieties as Industry, Columbus and Chautauqua. Spray with dilute lime-sulphur. Begin when the buds start and repeat every 10 days or 2 weeks until near picking time.

When Pruning, if a cane is cut that shows discolored pith, it may indicate the cane borer. Cut back to sound pith. Burn trimmings.

Wilted Foliage at any time indicates the cane borer. Cut out and burn.

GENERAL TREATMENT FOR RASPBERRIES, BLACKBERRIES AND DEWBERRIES.

Orange Rust may appear in May or June. It is easily identified by the bright orange color on the under side of the leaves. There is no method of preventing this trouble. As soon as it is found, the bush should be dug out and burned. If allowed to remain the disease will spread and destroy many plants.

Anthracnose, identified by the grayish spots on the canes (also on leaves but not conspicuous), is common in many berry fields. It does not yield to spraying unless very frequently done with Bordeaux mixture and this may not be profitable. If desirable, make the first spraying when the new canes are 6 to 8 inches high and repeat every two weeks during the growing season.

Cutting out and burning the old canes immediately after fruiting will be of some benefit. In starting a new field, make a special effort to secure healthy plants.

"Worms" or "Slugs" might appear at any time. Spray with an arsenical if early in season, but if near picking time, use hellebore or pyrethrum.

Cut out and burn gouty galls, tree cricket eggs or borers in stems.

GENERAL TREATMENT FOR STRAWBERRIES.

Examine the young plants before setting them. Pick off all discolored or diseased leaves. If root lice are suspected, dip the roots in strong tobacco-water.

After the growth starts, spray with Bordeaux and a poison to prevent the leaf spot and to destroy the leaf-roller insect that may be present.

For fruiting plantations, spray with Bordeaux before blossoming and repeat ten days to two weeks later. After fruiting if the bed is to be fruited again, mow and burn over quickly (as on a day when there is a wind, to avoid burning the crowns of the plants). If leaf rollers have been present, spray with poison after the growth has started again but before the leaves curl.

For strawberry root lice, see Michigan Bulletin No. 244 page 88.

GENERAL TREATMENT FOR POTATOES.

For the Potato Scab. Soak the uncut tubers for two hours in 30 gallons of water and one pint of formalin (can be secured of any druggist). This solution can be used several times. Do not put treated tubers back into crates or bags that held scabby potatoes. Make the treatment only a few days before planting if possible. Do not plant upon land that has recently grown crops of scabby potatoes or beets.

For the Blight and "Bugs." Begin spraying with Bordeaux mixture and poison when the "bugs" first appear, or when the plants are about 8 inches high, and repeat about every 2 weeks as long as the plants are growing. Spray often in warm, muggy weather; fewer sprayings are necessary in dry weather.

Use Bordeaux mixture (6 pounds copper sulphate and 4 or 5 pounds of lime to 50 gallons of water, and put in the poison, about ½ pound of Paris green or 2 pounds of arsenate of lead, or 1 quart of the stock solution of Kedzie mixture).

Dilute lime-sulphur will not do as a substitute for the Bordeaux for potatoes.

PREPARATION OF SPRAY MIXTURES.

STRONG LIME-SULPHUR.

Strong lime-sulphur to be used on dormant trees or bushes for scale insects, can be prepared in three ways:

By the old formula,

By reducing with water "the home made" concentrated wash.

By reducing with water the "commercial" concentrated wash.

The "Old formula" has been used for many years with good results and is very satisfactory. The formula is as follows:

Lump lime	20 pounds.
Sulphur (flour)	15 pounds.
Water (hot) to make	50 gallons.

The lime is slaked with a small amount of water (hot if lime is sluggish) and the sulphur is added, fifteen or twenty gallons of water are then added, and the mixture boiled. (It should take three-quarters of an hour or an hour of good boiling with frequent stirring.) When done the liquid should be amber colored and fairly clear. Strain, dilute with water (hot is preferable) to make (up to) 50 gallons, and apply warm, through a coarse nozzle.

If small quantities are required, use an iron kettle to boil it in. If larger quantities are to be used, live steam is preferable for boiling purposes, either in a tank or in barrels.

Applied just before the buds swell, it coats the branches in such a way as partially to hinder from settling down, such pests as the oyster-shell, scurfy scale, some aphids, and other insects.

HOME MADE CONCENTRATED LIME-SULPHUR WASH.

Growers, having cooking plants, can make the lime-sulphur wash in a "concentrated" solution. This may be an economy of time, as large quantities can be made early in the season and stored until needed.

It is difficult to make this wash of uniform strength. For this reason, every batch that is made must be tested with a hydrometer and diluted accordingly.

The difficulty of getting a solution of uniform strength, apparently depends on the lime, which varies in composition and strength. Lime that contains more than five per cent of magnesium oxide and less than 90 per cent of calcium oxide does not combine in the cooking with the sulphur in a way to make a good mixture. Special "spraying lime" is now on the market.

There are several ways of combining the lime and sulphur, but always there are two parts, by weight, of sulphur to one of stone lime. The following three formulas are in common use:

Stone lime	75 lbs.		60 lbs.		40 lbs.
Sulphur	150 "	or	120 "	or	80 lbs.
Water	50 gal.		50 gal.		50 gal.

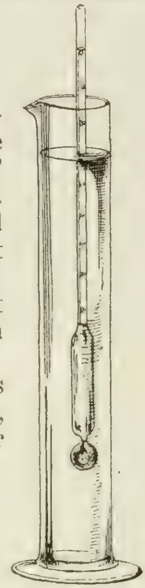
The lime is slaked to a thin paste and the sulphur is added. Boil for one hour and stir frequently. Water enough should be added so that there will be fifty gallons at the end of the boiling.

After it is cooked, if not to be used at once, it should be strained into a barrel which should be air tight, as exposure to the air causes the sulphur compounds to lose their value for spraying purposes. Each lot that is cooked should be tested with a hydrometer when cooled and diluted according to the dilution table when applied:

COMMERCIAL CONCENTRATED LIME-SULPHUR WASH.

There are several brands of the "commercial" concentrated lime-sulphur solution now upon the market. The use of these instead of the

home cooked kinds is becoming more and more common every year, especially by fruit growers who do not care to take the time or trouble to cook the material for themselves or if they do not have good facilities to do so. They are now reasonable in price,—of fairly uniform strength, and do add to the ease of getting ready to spray as all that is necessary is to dilute with the required quantity of water.



TESTING AND DILUTING CONCENTRATED LIME-SULPHUR.

Every "batch" of the home made concentrated lime- sulphur wash will have to be tested when cooled to determine its strength and it will be well to test the "commercial" brands. This testing is done with a Baume hydrometer. It is a simple instrument used to determine the weight and density of liquids. It is made of glass, is about a foot long, and has a graduated scale on the side.

It is absolutely necessary that the hydrometer be kept *perfectly clean*. If the solution is allowed to dry on it an accurate test cannot be made.

It can be purchased from dealers in druggists supplies or from Bausch and Lomb Optical Company, Rochester, N. Y., or Whitall Tatum Company, Philadelphia, Pa., or Taylor Instrument Companies, Rochester, N. Y.

(See last page for the rates of dilutions.)

DILUTE LIME-SULPHUR SOLUTION.

For spraying on the foilage of apples, pears, European plums and cherries but not on peaches or Japanese plums, grapes or potatoes.

This solution can be prepared for use in several ways.

First. The "commercial" concentrated lime-sulphur solution can be diluted to the proper strength.

Second. The "home made" concentrated lime-sulphur can be diluted to the proper strength.

Third. The solution can be made at any time and in any quantity as follows: Boil in a few gallons of water for one hour, *twice* as many pounds of sulphur as of lime, strain and dilute with water so there will be 8 pounds of sulphur to every 100 gallons.

Example: To make 100 gallons of spray solution, boil 8 pounds of sulphur and 4 pounds of lime as directed.

SELF-BOILED LIME SULPHUR MIXTURE.

This is a mixture of lime, sulphur and water and not like any of the other lime-sulphur sprays. It does not (when properly made) injure tender foliage and is very valuable for spraying peaches and Japanese plums.

The formula is:

Lump lime	8 pounds.
Sulphur	8 pounds.
Water	50 gallons.

The mixture can be prepared better by using thirty-two pounds of

lime, thirty-two pounds of sulphur, and eight or ten gallons of water, and then diluting to 200 gallons.

Place the lime in a barrel and add enough water to almost cover it, as soon as the slaking begins, add the sulphur, which should be run through a sieve to break up the lumps.

Stir constantly and add enough water to make a thick paste and then, gradually, a thin paste. As soon as the lime is well slaked, cold water should be added to cool the mixture and prevent further cooking. It is then ready to be strained into the spray tank, diluted up to the full formula, and used.

Care must be taken not to allow the boiling to proceed too far, if the mixture remains hot for fifteen or twenty minutes after the slaking is completed, some sulphur will go into solution and injury to the foilage may result.

The time of adding the cold water to stop the boiling depends upon the lime. With a sluggish lime all the heat in it may be needed, while with limes that become intensely hot, care must be taken not to allow the boiling to proceed too far.

SOLUBLE SULPHUR.

There has appeared on the market a form of sulphur that readily dissolves in water, and is recommended as a substitute for lime-sulphur. It has not been tested by this Experiment Station nor any other so far as we can learn. We therefore are not in a position to pass any opinion upon its value as a spraying mixture.

BORDEAUX MIXTURE.

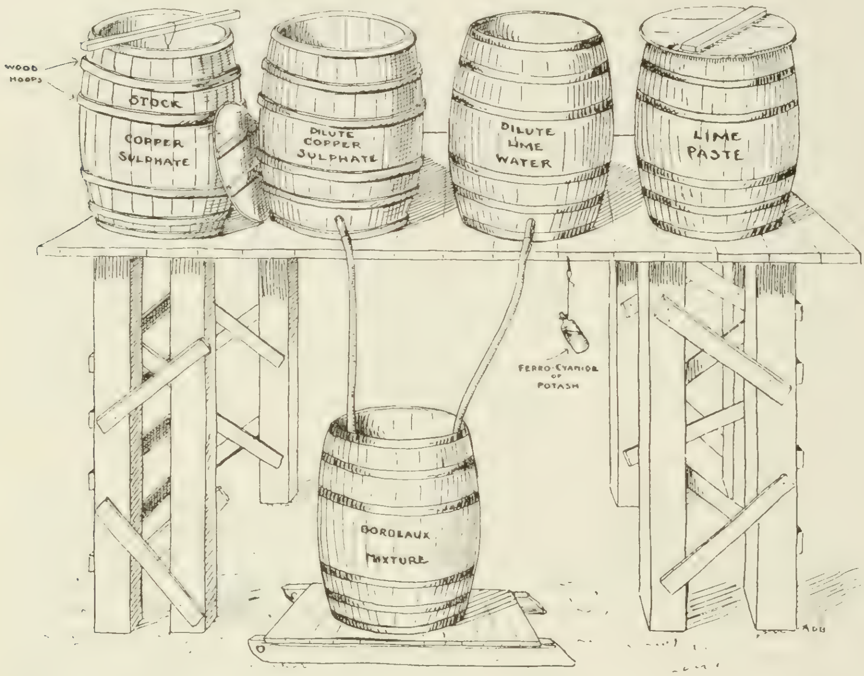
Bordeaux mixture is made of copper sulphate, lime and water.

These three substances are combined in various proportions, depending upon the kind of plant to be treated. For apples, pears, cherries and plums (except the Japanese varieties) the preparation is usually four pounds of copper sulphate, with about the same amount of lime, to fifty gallons of water. Poison is added as needed. The copper sulphate will readily dissolve in two gallons of hot water, to which should be added enough water to make twenty-five gallons or one-half barrel. Do not use an iron or tin vessel to dissolve this in, as the copper sulphate will destroy it, and besides the iron will spoil the Bordeaux. A wooden pail is good. Slake the lime into a thin paste and add water to make twenty-five gallons. Pour, or let these run together into a third barrel, and the Bordeaux is made. When it is emptied into the spray barrel or tank, it should be strained through a brass wire strainer to catch any of the coarse particles.

Whenever it is necessary to use a quantity of the mixture, it is desirable to have the lime and the copper sulphate in "stock solutions." A quantity of lime is slaked to a paste and held so by being covered with water. The copper sulphate, say fifty pounds, is placed in a clean gunny sack and suspended in a barrel (one with wood hoops is much to be preferred) containing twenty-five gallons of water. This will dissolve in about a day. One gallon of this "stock solution"* is equal to two pounds of copper sulphate.

* Always stir this "stock solution" before dipping any out, in order that what is used may be full strength.

A good quick way to combine these three substances is as follows: Put the amount of the "stock solution" of copper sulphate required in a barrel, and add enough water to make 25 gallons, or one-half barrel. Put about 7 pounds of the lime paste in a barrel and add 25 gallons of water, making a thin whitewash. Pour, or let these two run together into a third barrel, or directly into the spray barrel or tank, being sure to strain. When partly run in, test with ferro-cyanide of potash† to



make sure enough lime has been used. If Paris green, arsenate of lead, or any other poison is to be used, make it into a thin paste with a little water and add it to the Bordeaux mixture, which is now ready to be used.

COPPER SULPHATE SOLUTION.

Is copper sulphate dissolved in water. It is used by some growers to spray peach trees to prevent the leaf curl where a spraying for scale insects is not required. Two pounds of copper sulphate to 50 gallons of water is strong enough for this purpose.

† This chemical can be secured of any druggist. Ten cents worth dissolved in a pint of water will be enough for a season. Drop a very little in the Bordeaux, if a reddish brown color appears more lime must be added. If there is no discoloration, there is enough lime. Ferro-cyanide of potash is extremely poisonous, so observe great care in its use.

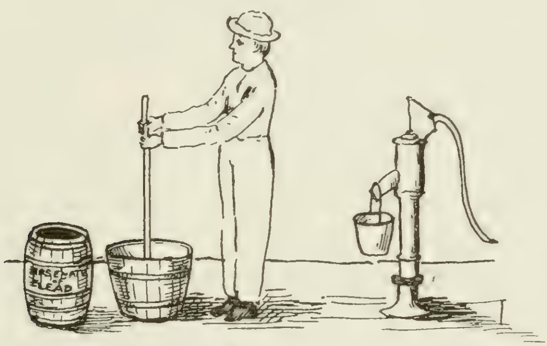
POISONS USED IN SPRAYING.

For Insects That Chew.

ARSENATE OF LEAD.

This poison is used very extensively. It can be secured for reasonable price, is ready to use at any time, does not easily injure the foliage and is the only poison that can be safely used in the lime-sulphur sprays.

It is usually sold in kegs or "kits" or small barrels in the form of a paste. Some companies have it in a powder form. This form usually costs twice as much or more per pound as the paste form and since it does not contain much water only one-half the amount in weight should be used as is recommended for the paste form.



A simple easy way to work the thick pasty arsenate of lead into a thin smooth paste (as it should be before using either alone or in something) is to put the amount required in a keg; add water and churn with a dasher. This is much quicker than to use a paddle.

PARIS GREEN AND LIME.

Always use lime with Paris green, it makes the poison stick better, beside greatly reducing the danger of burning the foliage.

For spraying from a barrel, the writer has found the following method very useful,—Place from one-quarter to one-half pound of good lump lime, or unslaked lime, in each of three or four tin pails which will hold about three quarts or less. Old cans or crocks will answer just as well. Add enough hot water to slake it into a thin cream or paste. Now add to each lot, one-quarter pound of Paris green, previously weighed out, and placed in paper bags, stir while the lime is hot and allow to stand for some time. Now measure out about forty-four gallons of water in your spraying barrel, and make a mark that will show how high it comes in the barrel, add the contents of one tin pail (viz., one-quarter of a pound of Paris green and one-half pound of quick-lime slaked) into the forty-four gallons of water in the barrel. Stir well and

spray. The pails or crocks can be used one at a time and refilled occasionally so that the stock is always on hand ready for use.

ARSENATE OF SODA—KEDZIE FORMULA.

This form of poison was originated at this Station by the late Dr. R. C. Kedzie.

This is a cheap effective poison that can be prepared at home. It is used by many of the grape growers of Michigan in combination with the Bordeaux mixture. It cannot be used in the lime-sulphur sprays. If used alone—as is sometimes done for potato bugs—slaked lime must be added or the foliage will be burned.

The formula is:

White arsenic	2 pounds.
Sal Soda (commonly called washing soda)	8 pounds.
Water	2 gallons.

Boil these materials in any iron pot or kettle *not used for other purposes* for about 15 minutes or until the arsenic dissolves, leaving only a small muddy sediment. Put this solution into a jug or other vessel that can be closed tightly and label "Poison."

One quart of this solution is equal to ½ pound of Paris green. For most spraying one quart in 50 gallons of water (with some lime) or Bordeaux mixture will be sufficient.

CONTACT INSECTICIDES, FOR INSECTS THAT SUCK.

KEROSENE EMULSION.

Place two gallons of ordinary kerosene in a warm place, either in a warm room or in the sun, and allow to become as warm as possible without danger from fire. Boil one pound of laundry soap or whale-oil soap in a gallon of soft water until completely dissolved. Remove the soap solution from the fire, and while still boiling hot, add the kerosene and agitate vigorously for ten minutes, or until the oil is emulsified, with a spraying pump by forcing the liquid back into the vessel from which it was pumped. When the liquid is perfectly emulsified it will appear creamy in color and will flow evenly down the side of the vessel when allowed to do so. Care should be taken to completely emulsify the oil and this is accomplished much more easily when the mixture is hot. This strong emulsion may now be readily diluted with water and used, or it may be stored away for future use. When cold it becomes like sour milk in appearance and should be dissolved in three or four times its bulk of hot water before diluting with cold water. If the water is at all hard, "break" it by adding a little sal-soda before putting in the soap.

Small amounts of this emulsion may be made by using the ingredients in small quantities but in the same relative proportion. It is used at the rate of eight or ten parts of water to one part of emulsion.

HELLEBORE.

White hellebore is the powdered root of a plant. It kills both by contact and as an internal poison. It may be applied either dry or in the form of a liquid. When used dry it should be mixed with three or four times its weight of flour or of plaster and then dusted on the insects. Applied wet, one pound should be mixed with twenty-five gallons of water and this liquid applied as a spray.

INSECT POWDER, BUHACH, PYRETHRUM.

This valuable remedy has one drawback, its cost. It is too expensive for use on a large scale. It kills insects through their breathing pores, but is harmless to man and beast. It will kill many of the insects of the garden if dusted on or applied as a spray at the rate of one ounce to two gallons of water.

Use the powder when it is undesirable to use poison, but never buy any unless it comes in tightly sealed packages. It loses its strength on short exposure to the air. An hour will suffice to weaken it. It must be applied from time to time, as it quickly loses its strength.

TOBACCO.

Tobacco in the form of dust may be obtained of the large manufacturers at a few cents a pound.

It is useful in destroying root-lice, especially woolly-aphis, in young trees, and in keeping insects from garden truck. For root-aphis, incorporate four to six handfuls of tobacco dust into the soil about the roots and induce a thrifty, healthy growth by using liberal quantities of nitrate of soda or barnyard manure early in the spring.

A *strong* infusion or tea made of waste will kill plant lice if sprayed when they first appear.

Nicotine is to be had now in concentrated form. It is more often sold about 40% strong. This may be diluted many hundreds of times before applying. As there is a diversity of grades and brands to be had, it will be well to use the strength recommended by the makers.

HYDRATED LIME.

Finely slaked lime is often useful because of its slight caustic properties. Against such larvae of saw-flies and beetles as are sticky, for instance those of the cherry-slug and asparagus-beetle, it may be used as a substitute for poison, if the latter, for some reason is undesirable.

Stone lime may be slaked with a small amount of hot water, using just enough to turn it to a dry powder. Such slaked lime is as fine as flour and very soft to the touch, having very little grit. Use a metal pail or kettle to slake in, as the heat may set fire to wood. Do not use too much water, and where possible, use freshly burned lime.

Hydrated lime may be used in making Bordeaux-mixture, but it is not as reliable as good, fresh, lump lime. It is less adhesive, not as strong (so more should be used) and more expensive. The one advantage is that it is a little easier to use.

Ground lime for making Bordeaux-mixture acts exactly like lump lime, if fresh, but this is difficult to determine as it is already in a powder.

CAUTIONS.

Do not spray while plants are in bloom. It is prohibited by law, except when canker-worm is present, and may destroy bees and other beneficial insects.

Do not dissolve copper sulphate in an iron or tin vessel. It will ruin the vessel and spoil the spraying solution.

For all spraying solutions containing copper sulphate, the pump must be brass or porcelain lined.

Wash out pump and entire outfit each time after using.

Use arsenate of lead on stone fruits in preference to other forms of arsenical poisons. It is less liable to burn the foilage.

Do not spray fruits or plants with poison within a month or more of the time when they are to be picked.

Keep all "stock solutions" covered to prevent evaporation.

WHEN THE CODLING-MOTH FLIES.

While the first week in August is a good average time for applying an arsenical spray for the second generation of the Codling-moth in Michigan, it is well to remember that seasons vary, and that the time set aims merely at an average. To determine exactly each year just when to get the highest efficiency out of a spray, for a particular locality, requires only a few hours of work, providing one can find some neglected apple trees near at hand.

First of all scrape off all loose bark-flakes from the trunk and limbs of several trees, thus destroying all the natural places for the hiding away of the cocoons. The scraping is most easily done while the bark is soft after a prolonged rain.

Next, make some bands of burlaps six or eight inches broad and three or four layers thick; place one around the trunk of each prepared tree and fasten with a headless wire nail driven into the tree so that the band can easily be removed. Do this in June so that the cloth may become weathered before the time for spinning. The larvae in searching for a good place to spin cocoons will find the bands, in the absence of other protection, and spin cocoons there.

Occasionally examinations during July will reveal these cocoons which should be carefully removed by cutting out a small bit of the cloth to which each is fastened.

Place all these bits of cloth with the cocoons attached in a cage made of a lantern globe or some other glass cylinder open at top and bottom, and then tie a bit of mosquito netting over the top to confine the insects when they come out of the cocoons. If the lantern globe is set on a little soil in a flower pot and the soil is kept just slightly moist, the chances of getting the moths out are increased.

Now put the cage thus prepared in a shady place where the sun cannot strike it to sweat it, and where the rain cannot penetrate. Outside of protection from rain and sun the conditions should be as near those of the outside as possible. Keep the soil in the pot just moist and look for the moths often during late July for they will hide down under the layers of burlaps and may be overlooked. When you see them in the cage, then you will know that they are laying eggs in the orchard and the time to spray is just before the young hatch and go into the fruit, which is about a week or ten days later, not afterward. Of course they do not come out all together but string along over quite a period.

TABLE OF DILUTIONS FOR CONCENTRATED LIME-SULPHUR WASH.

To spray for San Jose and Other scale insects.		Summer Sprayings for Apples, Cherries, and European Plums.	
If Baume test is	Amount below should be diluted to 50 gallons.	If Baume test is	Amount below should be diluted to 50 gallons.
33	6¼ gallons	33, 32 or 31	1¼ gallons
32	6½ gallons	30, 29 or 28	1½ gallons
31	6¾ gallons	27, 26 or 25	1¾ gallons
30	7 gallons	24, 23 or 22	2 gallons
29	7½ gallons	21, 20 or 19	2¼ gallons
28	7¾ gallons		
27	8¼ gallons		
26	8¾ gallons		
25	9 gallons	Summer Spraying of Pears.	
24	9½ gallons		
23	9¾ gallons		
22	10 gallons		
21	10½ gallons	33, 32 or 31	1 gallon
20	10¾ gallons	30, 29 or 28	1¼ gallons
19	11¼ gallons	27, 26 or 25	1½ gallons
18	11½ gallons	24, 23 or 22	1¾ gallons
17	12 gallons	21, 20 or 19	2 gallons

—H. J. EUSTACE,
R. H. PETTIT.

FOUL BROOD.

Special Bulletin No. 58.

The present bulletin is not the result of recent investigations, carried on at this station, nor does the writer claim or desire any credit for compiling its contents. It has been taken almost wholly from Farmer's Bulletin 442, of the U. S. Dept. of Agriculture, Bureau of Entomology, by permission. This bulletin was written in 1911, by Dr. E. F. Phillips, a man well and favorably known to many Michigan beekeepers.

The particular reason for issuing this bulletin at this time is to supply the means of recognizing both the more familiar American foul brood, and the newer, European foul brood, a disease acquired by Michigan quite recently. Furthermore the writer has found much discouragement and apprehension among the older bee-keepers, a few of whom have kept bees most of their lives and never met either one of these diseases. While such men are fortunate in never having had to deal with the diseases, they are working under a disadvantage unless they become familiar with the appearance and treatment in some way.

Dr. Phillips describes foul broed and its treatment as follows:

NATURE OF THE DISEASES.

"There are two recognized infectious diseases of the brood of bees, now known as American foul brood and European foul brood. Both diseases weaken colonies by reducing the number of emerging bees needed to replace the old adult bees which die from natural or other causes. In neither case are adult bees affected, so far as known. The means used by the beekeeper in deciding which disease is present is the difference in the appearance of the larvae dead of the two diseases. That the diseases are entirely distinct can not now be doubted, since they show certain differences in the age of the larvae affected, in their response to treatment, and in the appearance of the dead larvae. This is made still more certain by a study of the bacteria present in the dead larvae. Reports are sometimes received that a colony is infected with both diseases at the same time. While this is possible, it is not by any means the rule, and such cases are usually not authentically reported. There is no evidence that chilled or starved brood develops into an infectious disease or that dead brood favors the development of a disease."

NAMES OF THE DISEASES.

"The names American foul brood and European foul brood were applied to these diseases by the Bureau of Entomology, of this department, to clear up the confusion in names which formerly existed. By retaining the words "foul brood" in each name the disease-inspection laws then in force could be interpreted as applying to both diseases. These names were in no way intended to designate geographical distribution, since both diseases did exist and do now exist in both Europe and America, but were chosen primarily because they were convenient

and easily remembered names. Their only significance is in indicating where the diseases were first seriously investigated. It was particularly desirable to change the name of the disease now known as European foul brood, since "black brood" entirely fails to be descriptive and is misleading."

SYMPTOMS.

"The presence of a particular disease in a colony of bees can be ascertained most reliably by a bacteriological examination, since the symptoms are somewhat variable. It is possible, however, to describe the usual manifestations of the diseases, and the usual differences, so that the beekeeper can in most cases tell which disease is present."

AMERICAN FOUL BROOD.

"American foul brood is frequently called simply 'foul brood.' It usually shows itself in the larva just about the time that the larva fills the cell and after it has ceased feeding and has begun pupation."

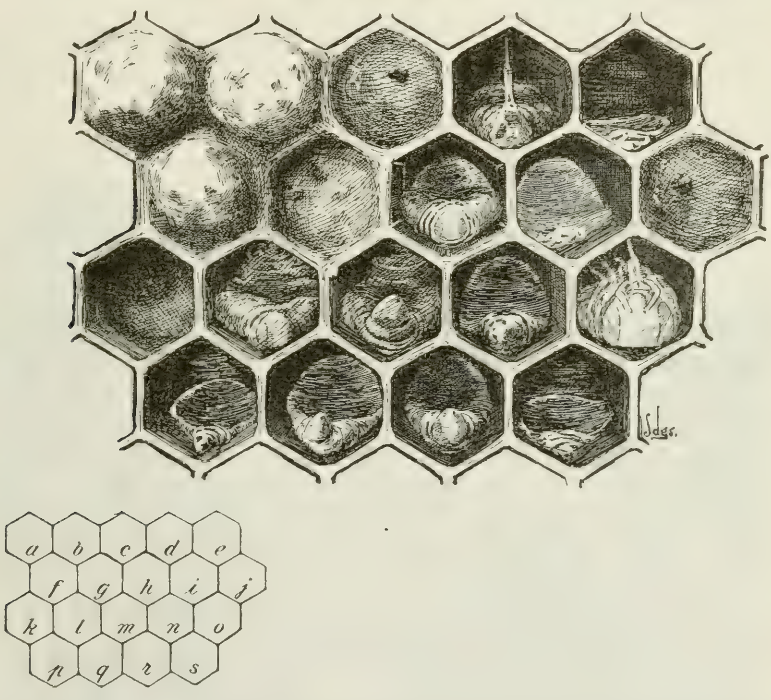


Fig. 1. American foul brood: *a, b, f,* normal sealed cells; *c, j,* sunken cappings, showing perforations; *g,* sunken cappings not perforated; *h, l, m, n, q, r,* larvae affected by disease; *e, i, p, s,* scales formed from dried-down larvae; *d, o,* pupae affected by disease. Three times natural size. From Farmers' Bulletin 442, U. S. Dept. of Agr., Bureau of Entomology.

"At this time it is sealed over in the comb (fig. 1, a, b, f). The first indication of the infection is a slight brownish discoloration and the loss of the well-rounded appearance of the normal larva (fig. 1, *l*). At this stage the disease is not usually recognized by the beekeeper. The larva gradually sinks down in the cell and becomes darker in color (fig. 1, h, m), and the posterior end lies against the bottom of the

cell. Frequently the segmentation of the larva is clearly marked. By the time it has partially dried down and has become quite dark brown (coffee colored) the most typical characteristic of this disease manifests itself. If a match stick or tooth-pick is inserted into the decaying mass and withdrawn the larval remains adhere to it and are drawn out in a thread (fig. 2), which sometimes extends for several inches before breaking."

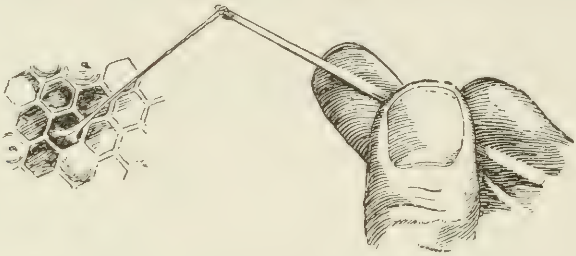


Fig. 2. The ropiness of American foul brood. From Farmers' Bulletin 442, U. S. Dept. of Agr., Bureau of Entomology.

"This ropiness is the chief characteristic used by the beekeeper in diagnosing this disease. The larva continues to dry down and gradually loses its ropiness until it finally becomes merely a scale on the lower side wall and base of the cell (fig. 1, e, p, s)."

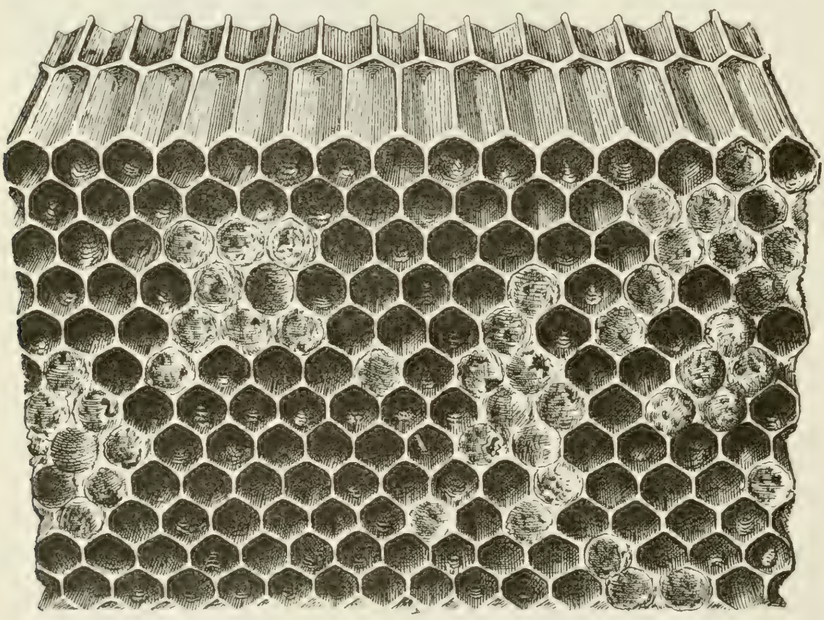


Fig. 3. American foul brood comb, showing irregular patches of sunken cappings and scales. The position of the comb indicates the best way to view the scales. From Farmers' Bulletin 442, U. S. Dept. of Agr., Bureau of Entomology.

"The scale formed by the dried-down larva adheres tightly to the cell and can be removed with difficulty from the cell wall. The scales can best be observed when the comb is held with the top inclined toward

the observer so that a bright light strikes the lower side wall (fig. 3). A very characteristic and usually penetrating odor is often noticeable in the decaying larvae. This can perhaps best be likened to the odor of heated glue."

"The majority of the larvae which die of this disease are attacked after being sealed in the cells. The cappings are often entirely removed by the bees, but when they are left they usually become sunken (fig. 1, g, c, j) and frequently perforated (fig. 1, c, j). As the healthy brood emerges the comb shows the scattered sunken cappings covering dead larvae (fig. 3), giving it a characteristic appearance."

"Pupae also may die of this disease, in which case they, too, dry down (fig. 1, o, d), become ropy, and have the characteristic odor and color. The tongue frequently adheres to the upper side wall and often remains there even after the pupa has dried down to a scale. Younger unsealed larvae are sometimes affected. Usually the disease attacks only worker brood, but occasional cases are found in which queen and drone brood are diseased. It is not certain that race of bees, season, or climate have any effect on the virulence of this disease, except that in warmer climates, where the breeding season is prolonged, the rapidity of devastation is more marked."

EUROPEAN FOUL BROOD.

"European foul brood was formerly called 'black brood' or 'New York bee disease.' The name 'black brood' was a poor one, for the color of the dead brood is rarely black or even very dark brown. European foul brood usually attacks the larva at an earlier stage of its development than American foul brood and while it is still curled up at the base of the cell (fig. 4, r). A small percentage of larvae dies after capping, but sometimes quite young larvae are attached (fig. 4, e, m). Sunken and perforated cappings are sometimes observed just as in American foul brood (fig. 1, c, g, j). The earliest indication of the disease is a slight yellow or gray discoloration and uneasy movement of the larva in the cell. The larva loses its well-rounded, opaque appearance and becomes slightly translucent, so that the tracheae may become prominent (fig. 4, b), giving the larvae a clearly segmented appearance. The larva is usually flattened against the base of the cell, but may turn so that the ends of the larva are to the rear of the cell (fig. 4, p), or may fall away from the base (fig. 4, e, g, l). Later the color changes to a decided yellow or gray and the translucency is lost (fig. 4, q. h). The yellow color may be taken as the chief characteristic of this disease. The dead larva appears as a moist, somewhat collapsed mass, giving the appearance of being melted. When the remains have become almost dry (fig. 4, c) the tracheae sometimes become conspicuous again, this time by retaining their shape, while the rest of the body content dries around them. Finally all that is left of the larva is a grayish-brown scale against the base of the cell (fig. 4, f, h), or a shapeless mass on the lower side wall if the larva did not retain its normal position (fig. 4, n, o). Very few scales are black. The scales are not adhesive, but are easily removed, and the bees carry out a great many in their efforts to clean house."

"Decaying larvae which have died of this disease are usually not ropy as in American foul brood, but a slight ropiness is sometimes observed.

There is usually little odor in European foul brood, but sometimes a sour odor is present, which reminds one of yeast fermentation. This disease attacks drone and queen larvae* almost as quickly as those of the workers."

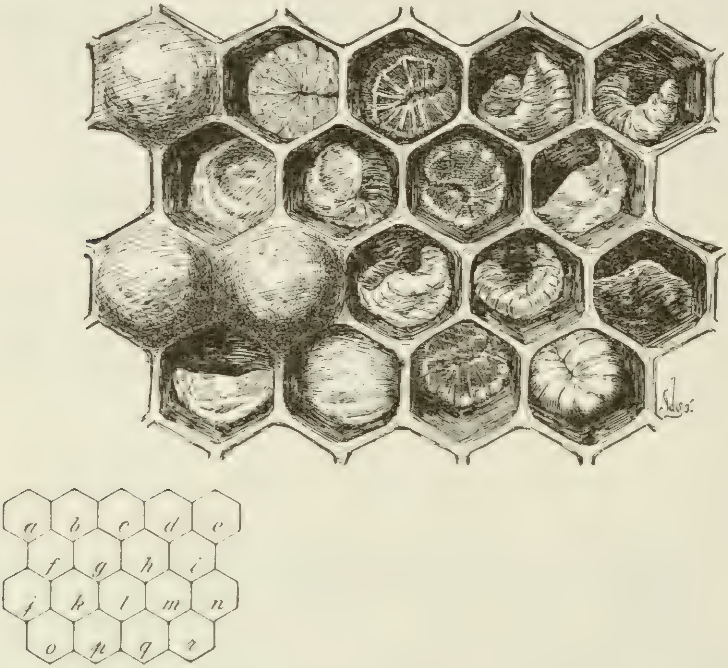


Fig. 4. European foul brood: *a, j, k,* normal sealed cells; *b, c, d, e, g, i, l, m, n, p, q,* larvae affected by disease; *r,* normal larva at age attacked by disease; *f, h, n, o,* dried down larvae or scales. Three times natural size. From Farmers' Bulletin 442, U. S. Dept. of Agr., Bureau of Entomology.

"European foul brood is more destructive during the spring and early summer than at other times, often entirely disappearing during late summer and autumn, or during a heavy honey flow. Italian bees seem to be better able to resist the ravages of this disease than any other race. The disease at times spreads with startling rapidity and is most destructive. Where it is prevalent a considerably larger percentage of colonies is affected than is usual for American foul brood. This disease is very variable in its symptoms and other manifestations and is often a puzzle to the beekeeper."

METHODS OF SPREAD.

"Both American foul brood and European foul brood spread from colony to colony and from apiary to apiary in much the same way. The common means of carrying the virus is in honey which has become contaminated. The disease may be carried when bees rob a hive in which a colony has died of disease or may be transmitted by the use of honey from diseased colonies for feeding bees. It is not always necessary that

* The tendency of this disease to attack queen larvae is a serious drawback in treatment. Frequently the bees of a diseased colony attempt to supersede their queen, but the larvae in the queen cells often die, leaving the colony hopelessly queenless. The colony is thus depleted very rapidly.

bees be intentionally fed for them to get disease from contaminated honey. Discarded honey receptacles which have contained honey from a contaminated colony, if not thoroughly cleaned, may contain enough honey to carry disease to a healthy apiary. This may occur in the vicinity of bakeries or confectionery shops, or may even occur when empty honey bottles are thrown out from private houses. It is also possible to introduce disease into a colony in introducing queen bees purchased from a distance, probably due to the use of contaminated honey in making the candy to supply the queen cages."

PRECAUTIONARY MEASURES.

"In combating diseases it is much better to prevent disease from getting a foothold than it is to eradicate it after it has begun its work. All beekeepers, wherever located, should practice the following precautionary measures:"

"(1) If a colony becomes weak from any cause, or if disease is suspected, contract the entrance to prevent robbing, and if robbing is imminent close the entrance entirely."

"(2) *Never feed honey purchased on the open market.* In case of doubt as to the source of honey feed sugar sirup."

"(3) If within the range of possibility, see that no honey that comes from diseased apiaries is sold in the neighborhood. This may sometimes be accomplished by cultivating the home market so that there will be no incentive for bringing in other honey."

"(4) In introducing purchased queens, transfer them to clean cages provided with candy known to be free from contamination, and destroy the old cage, candy, and accompanying workers. Of course, if it is certain that the queen comes from a healthy apiary this is not necessary."

"(5) Colonies of bees should never be purchased unless it is certain that they are free from disease."

"(6) The purchase of old combs or second-hand supplies is dangerous, unless it is certain that they came from healthy apiaries."

TREATMENT FOR BOTH INFECTIOUS DISEASES.

"The treatment of an infectious bee disease consists primarily in the elimination or removal of the cause of the disease. It is definitely known that American foul brood is caused by a bacillus named *Bacillus larvae*. In treating this disease, therefore, the aim of the manipulation is to remove or destroy all of the bacteria of this species. It should be remembered that the effort is not to save the larvae that are already dead or dying, but to stop the further devastation of the disease by removing all material capable of transmitting the cause of the trouble."

"The cause of European foul brood is not definitely known, but the same principles of treatment doubtless apply in this disease also. In all of the operations great pains should be taken not to spread the disease through carelessness. After handling a diseased colony the hands of the operator should be washed with water to remove any honey that may be on them. It does not pay to treat colonies that are considerably weakened by disease. In case there are several such colonies they

should be united to form strong, vigorous colonies before or during treatment."

"In discussing treatment it is assumed that hives with movable frames are in use. Box hives are a menace in regions where disease is present. These may be treated for disease by drumming the colony into another box and then hiving it like a swarm in a hive, but box hives are not profitable and are especially to be condemned where disease is present on account of the difficulty in inspecting and treating."

SHAKING TREATMENT.

"The shaking treatment consists essentially in the removal of all infected material from the colony, and in compelling the colony to take a fresh start by building new combs and gathering fresh stores. This is done by shaking the bees from the old combs into a clean hive on clean frames."

"Time of treatment.—The shaking treatment should be given during a flow of honey, so that other bees in the apiary will not be inclined to rob. If this is not possible the operation may be performed under a tent made of mosquito netting. The best time is during the middle of a clear day when a large number of bees are in the field. It is sometimes recommended that shaking be done in the evening, but this is impossible if many colonies are to be treated. The colony can be handled more quickly when the field force is out of the hive."

"Preparation.—All implements that will be needed, such as queen and drone trap, hive tool, and lighted smoker, should be in readiness before the operation is begun. A complete clean hive with frames is provided, as well as a tightly closed hive body in which to put the contaminated combs after shaking. An extra hive cover or some similar apparatus should be provided to serve as a runway for the bees as they enter the new hive. The new frames should contain strips of comb foundation from one-fourth to 1 inch wide. (Some of our Michigan beekeepers prefer clean frames containing no foundation.) Full sheets are not desirable, and if combs built on full sheets of foundation are desired they may be built later."

"Operation.—The old hive containing the diseased colony (fig. 5, A) is now lifted to one side out of the flight of returning field bees and the clean hive (B) set exactly in its place. The cover (G) is now taken off and a few frames (E) removed from the center of the hive. If unspaced frames are used, those remaining in the hive should be pushed tightly to either side of the hive, thus making a barrier beyond which the bees can not crawl as they move to the top of the hive after shaking. This largely prevents them from getting on the outside of the hive. If self-spacing frames are used, a couple of thin boards laid on the top bars on either side will accomplish the same result. The runway (D) is put in place in front of the entrance. The old hive is now opened for the first time. The frames are removed one at a time, lowered part way into the new hive, and with a quick downward shake the bees are dislodged. The frames are then put into the extra hive body (C) and immediately covered to prevent robbing. After all the frames are shaken the bees remaining on the sides of the old hive (A) are shaken out."

"If honey is coming in freely, so that thin honey is shaken out of the combs, cover the runway (D) with newspapers and shake the bees in front of the new hive (B), leaving all frames in place and the cover on. After the operation the soiled newspapers should be destroyed. In shaking in front of the entrance the first one or two frames should be so shaken that the bees are thrown against the entrance, where they can locate the hive quickly. They then fan their wings and the others follow them into the hive. If this is not done the bees may wander about and get under the hive or in some other undesirable place."

"After the bees are mostly in the new hive a queen and drone trap (F) or a strip of perforated zinc is placed over the entrance to prevent the colony from deserting the hive. The queen cannot pass through the openings in the perforated zinc and the workers will not leave without her. By the time that new combs are built and new brood is ready to be fed, any contaminated honey carried by the bees into their new hive will have been consumed and the disease will rarely reappear. If it should, a repetition of the treatment will be necessary."

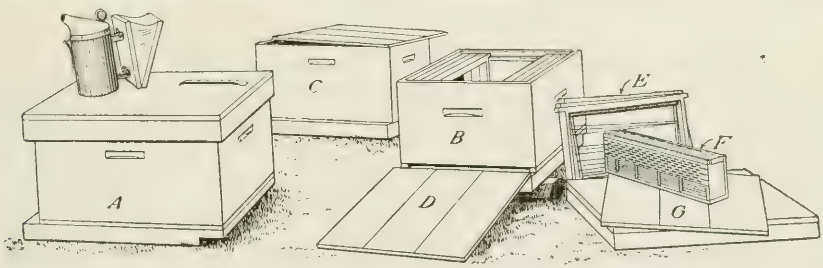


Fig. 5. Apparatus for shaking treatment: A, hive containing diseased colony (formerly in position of B); B, clean hive; C, empty hives to receive combs after shaking; D, hive cover used as runway; E, frames removed from B to give room for shaking; F, queen and drone trap; G, cover for clean hive B. From Farmers' Bulletin 442, U. S. Dept. of Agr., Bureau of Entomology.

"Saving the healthy brood.—The old combs are now quickly removed. If several colonies are being treated at one time it may pay to stack several hive bodies containing contaminated combs over a weak diseased colony to allow most of the healthy brood to emerge, thereby strengthening the weak colony. After 10 or 12 days this colony is treated in turn and all the combs rendered into wax. If only one or two colonies in a large apiary are being treated it will not pay to do this."

"Saving the wax.—Any but a very small apiary should have included in its equipment a wax press for removing wax from old combs. After the contaminated frames are taken to the honey house the combs should be kept carefully covered, so that no bees can reach them until the wax can be rendered. This should not be delayed very long or the combs may be ruined by wax moths. The slumgum or refuse remaining after the wax is removed should be burned. Contaminated combs should not be put into a solar wax extractor for fear of spreading the disease. The wax from contaminated combs may safely be used for the manufacture of comb foundation."

"Cleaning the hive.—The hive which has contained the diseased colony should be thoroughly cleaned of all wax and honey, and it is desirable that it be carefully disinfected by burning out the inside with a gasoline blue-flame torch. If this piece of apparatus is not available sev-

eral hive bodies may be piled together on a hive bottom and some gasoline or kerosene poured on the sides and on some straw or excelsior at the bottom. This is then ignited and after burning for a few seconds a close-fitting hive cover is placed on top of the pile to extinguish the flames. The inside of the hive bodies should be charred to a light brown. The careful cleaning and disinfection of frames always costs considerably more in labor than new frames would cost, but these also may be carefully cleaned and used again. Frames may be cleaned by boiling in water for about half an hour, but this frequently causes them to warp badly. The disinfection of hives and frames with chemicals is not recommended, as the ordinary strengths used are valueless for the purpose."

"Disposal of the honey.—If there is a considerable quantity of honey in the contaminated combs it may be extracted. This honey is not safe to feed to bees without boiling, but it is absolutely safe for human consumption. If there is a comparatively small quantity it may be consumed in the beekeeper's family, care being taken that none of it is placed so that the bees can ever get it."

"To put such honey on the market is contrary to law in some states. There is always danger that an emptied receptacle will be thrown out where bees can have access to it, thus causing a new outbreak of disease. It can be safely used for feeding to bees, provided it is diluted with at least an equal volume of water to prevent burning, and boiled in a closed vessel for not less than one-half hour counting from the time that the diluted honey first boils vigorously. The honey will not be sterilized if it is heated in a vessel set inside of another containing boiling water. Boiled honey can not be sold as honey. It is good only as food for bees, and even then should never be used for winter stores, as it will probably cause dysentery."

"The second shake.—Some beekeepers prefer to shake the bees first onto frames containing strips of foundation as above described, and in four days to shake the colony a second time onto full sheets of foundation, destroying all comb built after the first treatment. This insures better combs than the use of strips of foundation, but is a severe drain on the strength of the colony. Since it is desirable to have combs built on full sheets, the best policy is to replace any irregular combs with full sheets of foundation or good combs later in the season."

"The cost of shaking.—If the treatment just described is given at the beginning of a good honey flow, it is practically equivalent to artificial swarming and results in an actual increase in the surplus honey, especially in the case of comb-honey production. The wax rendered from the combs will sell for enough to pay for the foundation used if full sheets of foundation are employed. Since a colony so treated actually appears to work with greater vigor than a colony not so manipulated, the cost of treatment is small. If treatment must be given at some other time, so that the colony must be fed, the cost is materially increased. In feeding, it is best to use sugar sirup, or honey that is known to have come from healthy colonies."

TREATMENT WITH BEE ESCAPE.

"As a substitute for the shaking treatment just described, the bees may

be removed from their old combs by means of a bee escape. The old hive is moved to one side and in its place is set a clean hive with clean frames and foundation. The queen is at once transferred to the new hive and the field bees fly there on their return from the field. The infected hive is now placed on top of or close beside the clean hive and a bee escape placed over the entrance, so that the younger bees and those which later emerge from the cells may leave the contaminated hive but can not return. They therefore join the colony in the new hive. If desired, the infected hive may be placed above the clean hive and a tin tube about 1 inch in diameter placed from the old entrance so that the lower end is just above the open entrance of the new hive. The bees follow down this tube and on their return enter the new hive. When all of the healthy brood has emerged from the infected combs the old hive is removed. This treatment induces less excitement in the apiary and is preferred by many experienced beekeepers. Care should be taken that the old hive is absolutely tight to prevent robbing. The old hive and its contents of honey and wax are treated as indicated under the shaking treatment."

FALL TREATMENT.

"If it is necessary to treat a colony so late in the fall that it would be impossible for the bees to prepare for winter, the treatment may be modified by shaking the bees onto combs entirely full of honey so that there is no place for any brood to be reared. This will usually be satisfactory only after brood rearing has entirely ceased. Unless a colony is quite strong it does not pay to treat in the fall, but it should be destroyed or united to another colony. In case a diseased colony dies outdoors in the winter there is danger that other bees may have opportunity to rob the hive before the beekeepers can close the entrance. In case bees are wintered in the cellar it is more advisable to risk wintering before treatment, for if the colony does die the hive will not be robbed."

In Michigan, many of our most experienced and successful beekeepers are strong advocates of shaking twice. It may be due to our climatic conditions or to our particular methods of management, or to some other cause, in any case many of our best beekeepers are convinced that two shakes are more sure than one. Therefore if anyone has doubts as to the certainty of one treatment, it will be well to follow it with another, even if he does lose some bees thereby.

Many bee-trees are said to contain colonies infected with foul brood. To be sure, when a colony in a tree or the side of a house, dies, the combs are apt to be webbed up by the bee-moth, thus preventing further use of the space by the bees, but on the other hand it may happen that a fresh swarm may take possession and work for a time, eventually dying out, sometimes to be replaced again and again. Such a colony is a menace to every beekeeper within quite a radius, and in places where the disease exists, it will be well to put in some carbon disulphide or even a little gasoline and then to plug up the hole tightly or to fill it with cement. In case any colonies die during winter, the entrances to their hives should be tightly closed before the bees commence flying in the spring.

—R. H. PETTIT.

FOREWORD.

Technical Bulletin No. 11.

The present bulletin presents the results of an experimental investigation of the problem, "How Do Contact Insecticides Kill Insects?" The study has for the most part, and up to the present, dealt with agents that were believed to produce death by suffocation by stopping the breathing orifices. It is planned to carry on similar study along other promising lines in the hope of discovering facts that may be utilized in perfecting and rendering more efficient that great class of contact insecticides, which because of low efficiency or high cost are used only when stomach poisons will not apply.

This work is being done under the Adams Act, and aims to aid in helping in the control of noxious insects.

R. H. PETTIT.

HOW CONTACT INSECTICIDES KILL.

IMPORT OF THE PROBLEM.

The Study presented in this bulletin has been made under a project entitled, "How do Contact Insecticides Kill Insects?" The term "Contact Insecticide," as understood in the project, refers to all those substances which may kill through first coming into contact, or into some intimate relation with the outer surface of the insect-body, in contradistinction to those which must be eaten in order to become effective. Contact insecticides are applied in one of three forms—as dry powdered solids, as liquids (which may contain sludge), or in the form of gases or vapors. The latter are usually spoken of as fumigants.

By definition then it follows that such insecticides must become effective through one or perhaps both of two means:

1. Through influences conditioned only by proximity, or mere contact with the insect's external integument or with the tubular invaginations of the body wall—the tracheae and hind-intestine.

2. Through effects brought about after a possible absorption into the body tissues.

A few statements of possibilities in relation to the two means named here may now be permitted. In the first case the insect may be mechanically incumbered by the stickiness or hardness of the insecticide. The effect of pitchy and resinous washes in this respect is common knowledge. Still other possibilities are not so certainly known to hold true. With the more penetrating insecticides such as fine dusts, kerosene, soap-solutions, creolin and the miscible oils in general, it seems reasonable to suppose that the spiracles might be covered over, or that the insecticide might pass through them into the tracheae and thus interfere with the passage of air into the respiratory system. Besides, there are various fine openings through certain parts of the chitinous covering of insects, and the obstruction of such openings might be of serious consequence to the insect.

In case liquid or fumigant insecticides are absorbed, such absorption might take place through the fine openings in the chitin just mentioned, or through thin portions of the body integument such as may be found forming the delicate body-wall of many small insects. If any penetrating insecticide should pass into the tracheae or through the anal opening, it would seem that the chances of absorption through the thin walls of the tracheae or of the rectum would be still greater. Now in case any agent is absorbed through some of these avenues, it might then cause the death of the insect through one or more of several different ways. It might act as a general protoplasmic poison such as would cause coagulation or corrosion of the substance in any cells touched. It might be more specific, affecting the whole or some part of the nervous system, as a narcotic or paralytic; acting as a blood-poison; im-

pairing by some direct means the action of the muscles—especially those that control the respiratory movements and the heart-action. It might function as an agent whose presence would, in some manner, interfere with metabolism or with tissue respiration in a part or all of the body-tissues.

The above outline is merely a list of general possibilities by no means exhaustive in detail. It is given here in order to show the wide import of the question, "How Do Contact Insecticides Kill?" as well as to suggest likely lines for profitable investigation. Indeed, so few are the recorded experiments which are directed toward answering this question that any of the possibilities suggested might be investigated with the hope of gaining useful evidence. A few experiments and facts directly applicable have been lost sight of almost, and there has apparently been no concentrated work on the subject.

This experiment study has been carried forward, therefore, in the hope of gathering useful direct evidence of some possibilities which actually obtain and of bringing this evidence into such systematic relation to the subject as to clear the way for further detail work along promising lines.

I. ON THE EFFECTS OF CERTAIN GASES AND INSECTICIDES UPON THE ACTIVITY AND RESPIRATION OF INSECTS.

CAN CERTAIN CONTACT SPRAYS ENTER THE SPIRACLES AND PLUG THE TRACHEAE?

While, in the past, little has been done directly on the subject, it has been the common belief, nevertheless, for a long time, that (outside of the very caustic sprays) contact insecticides kill by stopping the breathing pores and thus suffocating insects. Numerous statements to this effect may be found in entomological text-books and bulletins. Since this idea is so commonly held, it was decided to determine first of all if such insecticides as kerosene, miscible oils, etc., do enter the spiracles and plug the tracheae of insects.

Kerosene is so nearly transparent that its presence in the tracheae of insects might be overlooked in a dissection, especially if present in only small amounts. Sudan III, which is a stain soluble in kerosene, giving it a strong red color, was therefore, used to make the fluid easily visible wherever it should go in the insect. After a thorough spraying with this colored kerosene, dissections of large insects like *Melanoplus femoratus* and the larvae of *Phlegethontius celeus* showed more or less of the colored oil in the larger tracheae. In the case of insects dipped in this colored oil for a few minutes practically all of the larger tracheae might be found filled with it. If a plant-louse with a delicate transparent body-wall was treated thoroughly with Sudan III in oil and then the color was *quickly* removed from the outer surface of the body by means of unstained kerosene or gasoline, the red oil could be seen through the transparent body-wall in some and often

in all the tracheae leading from the stigmata. Sudan III is insoluble in water. In a dissection of a large tomato worm made under water, therefore, tracheae containing Sudan III-kerosene may be traced beautifully. Fig. 1, Plate 1, is a photograph of such a dissection showing several tracheae filled with red oil (black in the photo) near the last two ganglia of the nervous system. It should be noted here that *Melanoplus femoratus* and the larva of *Phlegethontius celeus* are insects possessing a closing apparatus in each of the large tracheae leading from the spiracles. Kerosene is able to pass this closing apparatus when applied in sufficient amounts. Kerosene-emulsion and emulsions of the miscible oils were stained with indigo-carmine or with safranin and then shown to enter the spiracles of insects in the manner just described for kerosene. These two stains are carried in solution by the water particles of the emulsion. Indigo-carmine is entirely insoluble in absolute alcohol or clearing oils, so that insects treated with a spray or a dip of emulsion containing indigo-carmine may be afterward dropped into absolute alcohol and the stain will be precipitated just where it happened to be in the insect. Moreover, the tissue may then be cleared, embedded in paraffin and sectioned for histological study without the least danger of the stain spreading during the manipulation. Fig. 2, Plate 1, is a photomicrograph of a section of a plant-louse prepared according to the method just described after having been treated first with creolin emulsion containing indigo-carmine in solution. The picture shows a plug of the stain precipitated in a trachea at "a" where it had been carried by the emulsion.

By such methods it was therefore comparatively easy to demonstrate that these contact insecticides may enter the respiratory system of insects in amounts which are often great enough to plug the larger tracheae.

DOES PLUGGING OF THE TRACHEAE CAUSE DEATH BY SUFFOCATION?

Although the insecticide enter the tracheae, it scarcely seemed possible that the plugging could be so complete as to cause the comparatively rapid death which occurs to insects thoroughly treated with gasoline or kerosene. Almost every one has known of beetles or caterpillars which revived after having lain in water for several hours apparently dead. Such instances indicate that certain insects, at least, are not easily suffocated.

In an article published in the Journal of Experimental Zoology 1906, Eulalia V. Walling relates, among other experiments, instances of the complete recovery of respiration in grasshoppers brought into fresh air after a confinement in pure carbon dioxide for fifteen hours. Other specimens recovered the heart beat in fresh air after having been forty-eight hours in pure carbon dioxide. In hydrogen, this author says that grasshoppers retained the ability to perform respiratory movements, at intervals, over a period of five days continuous confinement.

Truly, these insects were not easily suffocated if they could do without oxygen for such long periods. The experiments seemed so very remarkable and so directly applicable to the project that it was decided to duplicate them, if possible, in case of the two gases named. For obtaining the gases pure, however, a different method was used—

especially since it did not seem advisable to employ acid and alkaline solutions of potassium permanganate for purifying the gases. Accordingly, after various preliminary experiments, an apparatus represented by Fig. 1, was arranged for enclosing insects in a current of pure hydrogen (i. e., hydrogen free from oxygen and carbon dioxide). The manipulation of this apparatus to obtain hydrogen known to be free from oxygen and carbon dioxide, and the method of carrying out the experiment may be described briefly. Referring to Fig. 1, hydrogen was generated in "A" by the inter-action of sulphuric acid and pure lump zinc. "B" contained potassium hydroxide. "C" represents a copper tube which was packed full of copper dust for the absorption of oxygen. The middle of this tube was kept hot by a flame. Over the connections at either end of the tube, cooling pads, on which cold water could drip, were placed. "D," "F" and "H," at the beginning of the experiment, contained potassium hydroxide solution made up at the rate of 120 grams of potassium hydrate in 80 c. c. of water; "E" and "G" contained pyrogalic acid in water—rate, 5 grams in 15 c. c. of water. "I" contained a weak solution of barium hydrate used as a final wash. "J" represents a cell which consisted of two pieces of light, clear plate glass between which was clamped a thick rubber gasket, having a rectangular opening through the center just large enough to hold snugly a specimen of *Passalus cornutus*. "K" was a glass tube large enough to hold conveniently three specimens of the same species. The flasks "L" and "M" were arranged in place so that a measured amount of a standard barium hydrate solution could be introduced at the proper time. The generator was so arranged that warm sulphuric acid could be introduced at any time through the long thistle-tube "T," or the exhausted solution could be forced out (should that be necessary) through "O." These operations could be performed without interfering with the slow, continuous passage of hydrogen under slight pressure, through the rest of the apparatus. The connecting-tubes, test-tubes and flasks were all of very heavy, strong glass, rubber being used only where absolutely necessary as shown. At the beginning of the experiment, the glass connecting-tubes between "D" and "E," "E" and "F," and between "G" and "H" stood up high in the position shown by the dotted line between "G" and "H." With every thing connected up thus, gas tight, a lively stream of hydrogen was kept going through the apparatus for six hours or more. Experience showed that it required almost that length of time to wash out practically the last trace of oxygen. Then, the strong connecting tubes between "E" and "F," and "D" and "E" were slowly forced down to the position shown. As the tubes were pushed down, hydrogen pressure caused some of the pyrogallic acid solution in "E" to run over into the potash of "F" and some of the potassium hydrate of "D" to run over into the pyrogallic acid of "E." Potassium pyrogallate which is a great absorbent of oxygen, was thus formed in an atmosphere of almost pure hydrogen, and after that any trace of oxygen escaping with the hydrogen through "C" was caught in the pyrogallate solutions of "E" and "F." Later the connection between "G" and "H" was forced down and so potassium pyrogallate was also formed in "H." In all these operations, care was taken that the solutions did not touch the rubber stoppers. The solution in "H" served for a test by which one might know that the hydrogen was free from all oxygen. Potassium pyrogallate, upon absorbing

the least trace of oxygen, turns brown, then dark. In the experiments, results of which are given here, "H" remained clear or light straw color. The solutions in "F" and "E" were stained but slightly. Assured, in this way of pure hydrogen, the beetles were prepared for the experiment. Four specimens of *Passalus cornutus* were selected, brushed clean, and weighed. From one of these beetles the elytra and wings could be removed with almost no injury whatever. Stop "S" was now closed. The wingless beetle was quickly placed, dorsal surface up, in the cell "J"—the other three beetles in "K." Connections were closed at once and "S" opened. Hydrogen flowed rapidly, due

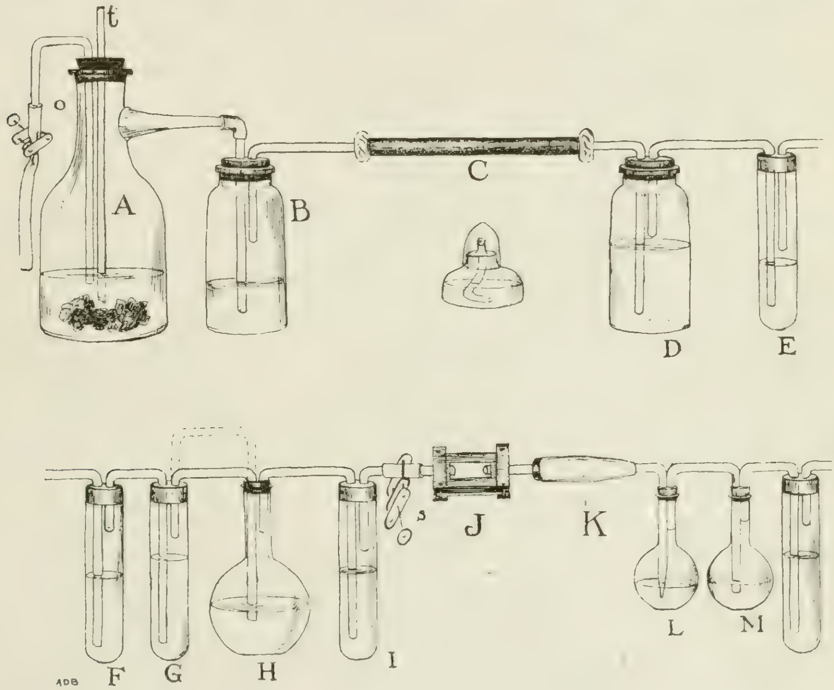


FIG. 1. Apparatus used to keep insects under observation in a continous flow of pure hydrogen.

to the storage and pressure gained while "S" was closed, so that any oxygen introduced with the beetles into "J" and "K" must rapidly have been washed through. Now, with cell "J" upon the stand of a binocular microscope, the heart, and some other internal organs of the naked beetle inclosed could easily be seen through the thin transparent chitin of the dorsal abdominal surface. Also the movements of beetles in "K" could be readily noted. After one-half hour, the small amount of oxygen introduced into "J" and "K" had been entirely replaced by hydrogen and, then the standard barium hydrate was carefully introduced into "L" and "M." The beetles were under constant observation for the first ten to twelve hours and at intervals after that. A slow stream of hydrogen was kept bubbling continuously to the end of the experiment.

Some results of these experiments may, perhaps, be best given in tabular form.

All text Figs. in this bulletin were drawn, under supervision, by Mr. A. D. Baurod.

TABLE I.

Beetles kept in a current of pure hydrogen.

Exp. No.	Number of beetles used.	Heart-beats per minute.	Movements.	Duration of Exp.	Recovery.	Carbon dioxide.	
						Total.	Amt. per 100 grms. of beetles per hour.
1	4 Passalus cornutus.	In air 72 to 74; in hydrogen, irregular 3 minutes; 38 at end of 5 minutes; and almost ceased in 20 minutes.	Excited 3 minutes, and nearly motionless thereafter.	6½ hours.	Heart-beats recovered in 20 minutes; leg and antennae movements in 30 minutes. Recovery complete.	0.00088 grms. or 0.44 c.c.	0.0021 grms. or 1.06 c.c.
2	4 Passalus cornutus.	In air, 77 to 78; in hydrogen, irregular 3 minutes; 60 at end of 4 minutes; 52 at end of 8 minutes; 38 at end of 20 minutes; ceased in 35 minutes.	Excited 3 minutes and nearly motionless thereafter.	24 hours.	Recovered entirely.	0.00308 grms. or 1.54 c.c.	0.0022 grms. or 1.11 c.c.
3	4 Passalus cornutus.	In air, 72; in hydrogen, ceased within one hour.	At first similar to above; 3 hours later the antennae and prothorax moved up and down slowly for 1¾ hours. This happened a few times after 9 hours. Leg movement was noted 14 hours later. One leg moved slightly between the 25th and 29th hours.	38 hours.	Two did not recover even the heart-beat. Two did recover heart-beat and slight leg movement. None recovered entirely.	0.00648 grms. or 3.24 c.c.	0.00239 grms. or 1.21 c.c.
4	2 Passalus cornutus.	Much the same.	Much the same.	40 hours.	No recovery at all.	0.00418 grms or 2.09 c.c.	0.0031 grms. or 1.57 c.c.

The temperature of these experiments ranged from 68° to 72° F. The use of barium hydrate as an absorbant for carbon dioxide is so well known that but little review is needed here. Sulphuric acid $\left(\frac{N}{10}\right)$ with rosalic acid as an indicator seemed most convenient for use in the titrations. After a little practice, with proper care, constant titrations accurate to a drop could be obtained. If only a very slight precipitate of barium carbonate was found in the barium hydrate flask, the titration could be made directly. If the precipitate were considerable, it was necessary to filter before titrating in order to determine the exact end-point with certainty. The hydrate was filtered boiling hot into a flask containing a little boiling water. The precipitate was washed *thoroughly*; and the whole operation was carried out in an atmosphere containing a minimum of carbon dioxide. By determining the value of the barium hydrate solution at the beginning and at the end of the experiment, the value of the carbon dioxide absorbed by it, in terms of $\left(\frac{N}{10}\right)$ acid, could be found. Each cubic centimeter of $\left(\frac{N}{10}\right)$ carbon dioxide is equal to 0.0022 gram of carbon dioxide.

From Table 1 it may be seen that the beetles were able to recover after many hours confinement in hydrogen. During this confinement in pure hydrogen small amounts of carbon dioxide were given off. After death the rate of giving off this carbon dioxide increased a little.

For the experiments in which insects were confined in carbon dioxide, that gas was obtained in its purest form from the action of weak sulphuric acid dropping on pure sodium bicarbonate which was packed into the bottom of the generator in the form of a paste. By this means a current of carbon dioxide over 99.5% pure could be obtained. The results secured on beetles with this gas were very similar to those in which hydrogen was used except that the heart action lasted longer in carbon dioxide. When *Passalus cornutus* was confined in this gas, the heart-beat at first quickened and became irregular. It then slowed and ceased, usually in about three minutes, only to begin again after about twenty minutes, slowly, at sixteen to twenty beats per minute. Alternate ceasing and beating again occurred thus for several hours but the periods of beating gradually became shorter, farther apart, and the heart weaker until finally it ceased altogether. Recovery in case of this species, was scarcely ever complete after a longer period of exposure than twenty-four hours. A pupa of *Phlegethontius celeus*, however, recovered perfectly within twelve hours after an exposure to carbon dioxide of ninety-six hours. Several other insects, among which were crickets, grasshoppers, certain Diptera and caterpillars were also tried. All would quickly become motionless, but all could recover again in fresh air after several hours confinement in the absence of oxygen. Caterpillars could endure the confinement for fully as long periods as the beetles and then recover afterward. None of the experiments, however, showed that insects could live longer in hydrogen than in carbon dioxide.

After searching some of the older literature on the subject of respiration, it was interesting to find several experiments recorded years ago (and practically lost sight of) which point to this same fact—viz. that insects are by no means easily suffocated. Burmeister[1] in 1836

1. Burmeister; A Manual of Entomology; Trans. by Shuckard, London, 1836.

says he has known certain beetles to recover after having been immersed in spirits for twelve hours. Sorg,[1] 1805, relates many experiments on insects confined in air, carbon dioxide, oxygen, etc., all of which he thought went to show that insects use oxygen and give off carbon dioxide, but that they can endure on little oxygen. Some of them as *Papilio crataegi,* this author says can use nearly all the oxygen out of a limited quantity of air. G. R. Treviranus[2] in 1814 says that insects show great variation in their dependence of life upon the passage of air into the respiratory system. "Es findet aber unter den Insekten eine grosse Verschiedenheit in der Abhängigkeit des Lebens von dem Zutritt der Luft zu den Respirationsorganen statt." He then relates several experiments with various insects treated either with water or with oil, all of which seem to show that after complete stoppage of the spiracles it is several hours until death results. So far as I can find, he does not tell, anywhere, what kind of oil he used. Finally as early as 1670, Robert Boyle[3] made a long series of experiments in which he confined different animals under the receiver of his air-pump. He tells how grasshoppers, gnats, caterpillars, beetles, ants and flies, when confined in as nearly a vacuum as he could obtain for several hours, recovered after having been again returned for some time to fresh air.

It was no longer doubted, therefore, in this study, that insects are hard to suffocate but the *bare possibility* still remained that the oil sprays might plug the tracheae effectually enough for the required length of time, to do just that thing.

Experiments were arranged which proved conclusively that carbon dioxide and oxygen can diffuse slowly through thin layers of kerosene. About 80 c. c. of carbon dioxide were confined in a receiver above a layer of kerosene (nearly one-quarter of an inch thick) which floated on water. After six hours, less than half the carbon dioxide was visible. The remainder had been absorbed by the water through the thin layer of oil. If, now, air were placed instead of the carbon dioxide of the last experiment and the water beneath the oil substituted by a good absorbent of oxygen (as potassium pyrogallate), the oxygen of the confined air became slowly absorbed.

But still, the fact that these two gases can pass slowly through a film of oil did not remove entirely the possibility that death to an insect might occur through a stoppage of the spiracles by kerosene. The diffusion of gases might not be rapid enough to maintain life. On that account, search was made for an oily substance, as capable of plugging the tracheae as kerosene, but from which insects would recover after treatment. It was found that if healthy specimens of *Passalus cornutus* were dipped into pure oleic acid (tinged with Sudan III for a marker) for two minutes until all the larger tracheae were filled, the insect would become apparently lifeless as if drowned. When removed at once in this condition and all superfluous oil taken up with good absorbent paper, the insect would begin to revive after ten to fifteen minutes. Shortly after that, respiratory movements would start and in a few

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1. Sorg; Disquisitiones Physiologicae circa Respirationem Insectorum et Vermium; 1805.
2. Treviranus, G. R.; Biologie oder Philosophie der lebenden Natur fur Naturforscher und Aerzte, Vol. IV, 1814, p. 151.
3. Boyle, Robert; The Phil. Transactions of the Royal Society o London, Vol. V. pp. 497-508.

hours entire recovery resulted. Several beetles were tried in this way. All recovered so as to walk and feed. They were kept under observation for five days. When the beetles were dipped in the same manner in kerosene or gasoline there was no recovery. Death was certain and comparatively rapid—especially so in the case of gasoline. *Oleic acid is not equally harmless to all insects nor is it as harmless as water to any, but it is a heavier oily substance than kerosene and as capable of plugging the tracheae in the beetle, *Passalus cornutus*, as the latter oil. There could be but one conclusion. Oil in the tracheae (depending upon the amount present) interfered with the passage of air, but the rapid death from kerosene and gasoline was not due to plugging of the tracheae alone.

Furthermore, it was noticed that air saturated with the vapor of gasoline at 72° F. killed most insects nearly or quite as rapidly as the liquid itself. The presence of a very small amount of carbon disulphide vapor in the air kills insects, as is well known. Death from the vapor of these liquids could scarcely be due to a plugging of the tracheae. Neither might it be due, alone, to the fact that the vapor dilutes the air of its oxygen, since experiments confirmed Sorg's early conclusion in 1805 that some insects may use practically all the oxygen from a limited quantity of air. Indeed, as will be shown later, *Passalus cornutus* can extract all the oxygen from a limited supply of air before death results. Tests were tried further with the vapors of kerosene, benzol, to-bak-ine, hydrocyanic acid, chloroform, special kreso dip, creosote, aniline oil, pyrethrum, carbon disulphide, pyro cresol, creolin, chloro-naphtholium, sulphur dioxide, common ether, neutral oil kreso, crel oll and zenolium. It was found that the vapors of all these insecticides affect insects, and at temperatures ranging from 70° to 84° F., the vapors from the more volatile substances kill many kinds of insects. *Ceuthophilus* sp. was especially sensitive. (Miscible oils, besides containing a varying amount of some volatile body, are also more or less alkaline.) Any vapor coming from peanut oil, castor oil, oleic acid and the common soaps showed little or no effect at the temperatures named. Results of some of these tests have been tabulated in Table II.

*The oleic acid used must be pure. It will not do to leave it exposed to the air for a few months.

TABLE II.

Comparative action of a few substances on insect-activity.

Fluid used.	Species.	Influence on activity.	Time.	Recovery.
Tracheae filled with oleic acid (Sudan III).	Passalus cornutus.	When first immersed, insect became excited and struggled; then became nearly quiet in 2 to 3 minutes. Then removed at once to absorbent paper.	Immersed 2 minutes.	Recovery began in 15 minutes Complete after a few hours.
Tracheae filled with kerosene (Sudan III).	Passalus cornutus.	When first immersed, insect was excited; became nearly quiet in 2 minutes. Then removed to absorbent paper.	Immersed 2 minutes.	Slight leg movement shown after 15 minutes, but no further recovery—death.
Tracheae filled with gasoline.	Passalus cornutus.	Excited when first immersed, quiet in less than a minute and became rigid. Removed to absorbent paper.	Immersed 2 minutes.	No signs of recovery. Dead.
Vapor of Benzol at 72° F.	Ceuthophilus.	Became sick and almost at once passed into contortions.	In the vapor 3 minutes.	Dead.
Xylol vapor at 68° F.	Ceuthophilus.	Excited for 2 minutes. Became helpless in 6 minutes.	8 minutes.	Died without complete recovery.
Wet with mist of gasoline.	Green Rose Aphids.	Became motionless in 3 to 4 minutes.		No recovery.

DO OIL INSECTICIDES AND GASES PASS INTO THE TISSUES OF THE INSECT-BODY?

It had now been shown definitely that the oil-sprays, pyrethrum powder, and such common contact insecticides could not possibly be so effective as they are, through plugging the tracheae alone, and that their vapors at ordinary temperatures were often as effective as the liquid or powder itself. The question naturally arose, then, as to whether these insecticides might not become mainly effective after having been absorbed into the body tissues. So very little of the carbon disulphide vapor or hydrocyanic acid gas is necessary to bring about death to most insects that it might seem very reasonable to suppose they are absorbed. Equally reasonable, then, would it be to believe that the vapors of kerosene, and other volatile insecticides are absorbed. but direct evidence may be had. From the gases which are very poisonous to insects, hydrogen sulphide was selected for a test to determine whether it becomes absorbed by the tissues before death results. This gas gives abundant colored precipitates with the salts of certain metals in solution. For instance, with lead acetate a black precipitate of lead sulphide results and in a solution of cadmium chloride, the sulphurated hydrogen throws down yellow cadmium sulphide. A method of using this test on insects, therefore, readily suggested itself. Insects were placed in an atmosphere containing a large percentage of the poisonous gas and left there until nearly dead. They were then removed and a warm solution of one of the salts named was quickly injected into the body tissues by means of a fine hypodermic needle. The presence of the gas in the body was proven very decisively by the precipitate that resulted. The hot lead acetate and cadmium chloride solutions, when used as killing agents on insects that had not been just treated with H_2S, did not blacken the tissues. If the white grub of a beetle were used, the rapid progress of the precipitation during the

injection could be observed readily through the body-wall. Since these precipitated sulphides are insoluble in alcohol or oils, histological sections of tissues treated by this method could be prepared. Figure 3, Plate 1, is a photomicrograph of such a preparation. In this section the cells are not stained, as with a dye, at all. The photograph shows simply the distribution of lead sulphide precipitate through the tissues. Fig. 2, Plate II, is the photomicrograph of another similar preparation. Note that the precipitate is not distributed in all tissues alike.

Observations made on insects killed in sulphur dioxide gas showed that the proteids of the body were precipitated rapidly by a high percentage of this gas. In case death was being brought about from the vapor of gasoline, carbon disulphide, chloroform, or other similar volatile substances, however, there was no immediate visible change in the tissues of the insect. No method for obtaining satisfactory color reactions in the tissues, with such fluids, was found. The odor of the vapors might remain on insects some little time after they were removed to fresh air; but the best way of proving that they are absorbed was found in the actual volumetic measurement of the amount taken up. The method of doing this can best be given later in this paper. (Page 49.)

When insects were dropped into kerosene or gasoline stained with Sudan III, the color did not begin to penetrate the tissues noticeably for several hours. It then slowly made its way. Also it was noticed that the fat body was affected, but not until after several hours. Fig. 5, Plate 1, represents a section through the body of a cabbage worm which had lain in kerosene three hours before being fixed in an alcoholic picric acid solution and then prepared for sectioning. Tissues, in this section, are in just as good condition histologically as those shown in Fig. 4, same plate, although the latter is from a section of an insect killed directly by hot alcoholic picric acid. Caterpillars dropped into warm gasoline and left for twelve to fifteen hours, however, had most of the fat removed in solution in the gasoline. Clearly, then, death from these two liquids resulted long before the liquids, as such, had time to penetrate the body.

Alkaline washes were tried; full strength Takanap soft soap, full strength creolin, and various dilutions were used. It was found that such washes might be applied to one portion of the body of a caterpillar, like the cabbage worm for example, until that part was insensible and apparently dead while other parts of the body were alive and yet able to move. Even weak alkaline washes, if kept upon a certain part of the body long enough (fifteen to thirty hours) would be able to penetrate the chitin and kill at the place where the application was made—other portions of the body remaining alive for a time. The proof that this slow penetration took place was found in the effect upon the tissues. Fig. 6, plate 1, is a photomicrograph of a section through a portion of the body of a cabbage worm treated with creolin for thirty hours. The untreated portion of the body of this insect was alive up to the time the tissues were fixed for sectioning. Note that the fat body has gone to pieces and that the muscular tissue has also been attacked. It was instructive to compare such preparations with those that had been treated with kerosene (Fig. 5, Plate 1) or with those on which fixing agents, only, had been used. The two facts then be-

came very apparent: first, tissues of caterpillars were not visably affected by kerosene and gasoline until several hours after death had resulted: second, an alkaline wash might penetrate the chitin, gradually dissolving the fat body and muscles in the treated portion of the body while the rest of the body was alive. In the latter case, it seemed reasonable to attribute final death to this solvent action. Likewise, when corrosive sublimate was used on bed-bugs, or other delicate-bodied insects, it slowly penetrated the chitin and precipitated the proteids of the tissues, so that death might reasonably be attributed to that action. There was apparently, no measurable period of time between the condition showing the usual attributes of death in a tissue and the occurrence of the precipitation mentioned. This was true in case of all the solutions usually spoken of in histological methods as "fixing or killing agents." Alcoholic solutions of these agents (where such can be made) penetrate chitin more rapidly than water solutions. Heat, which causes coagulation of the proteids is also such an agent. It penetrates chitin more quickly than any other fixing agent.

EFFECT OF CONTACT INSECTICIDES AFTER ABSORPTION.

Proof that some of the liquid contact insecticides become absorbed by insects was seen in the readily visible effects upon the body tissues. For that reason, the effects of these liquids have already been mentioned under the last heading. It was noted there that kerosene, gasoline, and indeed a large part of the list of fluids whose vapors were found to affect insects, made no visible change in the tissues for several hours after they were applied externally in abundance. In fact, death resulted before the liquids, as such, had penetrated the body, and physiological disturbances began at almost the moment insects were treated with these liquids or their vapors. It appeared, then, that the volatile portions of the fluids penetrated into the tissues rapidly. Attention was therefore given to a study of some of the important physiological effects of the fluids in question. The work done on this phase of the subject might be classified under two general headings: (a) effects upon the general activity and heart-action and (b) effects upon respiration.

(a) EFFECTS UPON THE GENERAL ACTIVITY AND HEART ACTION.

In order to study the influence of vapors upon the general activity and behavior of insects, they were confined in the air of broad shallow vessels, upon screens, above the fluids to be used. A vessel containing its fluid, was left standing for some time until the air confined was saturated with the vapor at the temperature of the experiment. The insect was then introduced upon the screen and observations taken. *Passalus cornutus* and *Ceuthophilus* sp. were the insects principally used, but plant lice, Diptera, a few Hymenoptera and others were also tried during the course of the experiments. For making a study of insect activities in such gases as carbon-dioxide, hydrogen, or nitrogen, the confinement was made in glass containers above mercury. One other method for studying the behavior of *Passalus cornutus* in hydrogen has already been described and the apparatus figured; see Fig. 1. It was by means of the cell "J" represented in this figure that the effect

of various liquids and vapors upon the heart action of *Passalus cornutus* could be readily studied. A beetle, elytra and wings removed, could be so placed in the cell that the dorsal surface of the abdomen touched the face of the upper thick glass cover. In that position, upon the stand of a binocular microscope, the rate and peculiarities of the heart-beat in air alone, could be carefully observed for some time. Then, when the liquid, vapor, or gas was passed into the cell through its tube connections, the influence upon the heart could be followed from the very start.

The insecticide vapors and gases used in connection with the study of effects upon movements and the general behavior are as follows: gasoline, kerosene, benzol, xylene, turpentine, creosote, aniline oil, carbon disulphide, chloroform, ether, pyro cresol, special kreso-dip, creolin, chloro-naphtholium, crel oll, zenolium, to-bak-ine, pyrethrum, hydrocyanic acid gas, carbon dioxide, nitrogen and hydrogen. The first five of these, also pyrethrum, carbon dioxide and hydrogen were used in studying the effects upon heart activity.

It is not of advantage, here, to relate separate experiments with each of these substances. Results varied considerably with different substances used on the same species as well as with the same substance upon different species and individuals. But certain general facts seemed of importance in this study.—If insects were treated with any of these substances in exceedingly small amounts at first, and the amounts were afterward gradually increased, a period of excitement was usually very noticeable. In some instances this was mild and in others, the insect rushed about in a perfect frenzy. This period was followed by one of uncertain, or uncontrolled movements and finally by the entire loss of movement and sensibility. The latter stage was followed more or less rapidly by death. In the second stage with uncontrolled movements the insects were often sick and would spew secretions from the mouth. This was almost invariably the case with *Ceuthophilus* in gasoline vapor. The length of time that any one of these stages would last varied widely with the substance, the amount of it used, and with the insect. The heart action during the period of excitement became greatly quickened and irregular. Sometimes the pulsations followed one another along the dorsal vessel with such rapidity they could not be counted. Then the action would stop entirely for a little while. When the excitement period of the insect had passed, the heart action was still apt to be irregular but the beating always became slower and gradually fell far below the normal. As a rule, however, the heart action was one of the last visible signs of life to disappear. The time limit, for which insects could endure the period of absolute loss of motion and heart action, varied as much or more than any other one thing. In case of some insecticides there might be no recovery at all of certain species, if this stage were reached. In fact, *Ceuthophilus* was almost certain to die without complete recovery, if even the second stage were reached and the insect became sick from gasoline vapor. Insects plunged into large amounts of the vapor or gas of any of the very volatile fluids passed a quick excitement stage, followed almost instantly by absolute loss of motion. Carbon-dioxide, nitrogen, and hydrogen produced quick insensibility, too, as a rule; but if these gases were admitted gradually, the general symptoms al-

ready described appeared. That is to say, the gradual exclusion of oxygen brought about general effects, in behavior and actions much resembling those of chloroform, ether, gasoline and the other similar agents mentioned in this connection. In other words, the general symptoms of the dearth of oxygen resembled narcosis. The chances of recovery were not equally good with all the agents given in the list. Hydrocyanic acid gas is irritating and extremely poisonous to insects. It can scarcely be classed with the narcotic agents. Yet, beetles often recover from it after having been deeply under its influence and apparently dead. Chloro-naphtholium, zenolium and similar miscible oils were irritating when the liquids themselves were applied, but their vapors seemed truly narcotic. The one striking and perhaps significant fact in all these observations was that nitrogen or hydrogen, i. e., lack of oxygen, should produce effects so closely resembling the narcosis of chloroform, gasoline vapor and the rest.

(b) EFFECTS UPON RESPIRATION.

When the general effects upon behavior and heart activity had been correlated, for the fluids listed, as just described, it became interesting to know what effect these same substances produced on the rate of the respiratory exchange. Furthermore, in a study of this phase of the subject, it might be determined whether a plugging of a part or all of the tracheal trunks of an insect by kerosene would really reduce the amount of carbon dioxide given off and oxygen used.

Other workers, studying the respiration of higher animals, had found that, food and other conditions remaining as nearly as possible the same, an increased excretion of carbon dioxide by an animal accompanied an increase in the oxygen used. Likewise a decrease in the one meant a decrease in the other. In view of this fact, it was decided to study the effects of the fluids upon the rate of carbon dioxide excretion only—especially since accurate means of determining the oxygen used by an insect did not at first suggest itself. Preliminary experiments soon showed that accurate determinations of the carbon dioxide excreted by treated and untreated insects could be made with the help of the very simple apparatus represented by Fig. 2. As may be seen, it consisted of a flask (2260 c. c. capacity) from the rubber stopper of which hung a brass wire cage for the insects. At the lower end of the cage a small cap of muslin was fastened to catch any excreta which might sift through the screen. Beneath the cap, could be hung a small wad of absorbent material for the fluid-insecticide, in case the influence of its vapor was to be tested. In the bottom of the flask was placed a measured amount of standard barium hydrate solution. This standard barium hydrate was kept in stock in a large bottle protected from the air by a carbon dioxide filter. Arrangements were made for drawing off and accurately measuring out the solution as it was needed, by the gravity method, using a burette with a two-way cock.

Before starting an experiment, the flask was connected up between a carbon dioxide filter and an aspirator. Thus the air in the flask could be rendered entirely free from carbon dioxide in about 20 minutes. After that, the standard barium hydrate could be quickly introduced

from the burette into the flask and the latter closed with a rubber stopper. In the meantime the beetle was prepared, weighed and placed in the cage. The precaution of keeping beetles in the open air for one-half hour to an hour before being used in the experiment was found important. Then, the cage (with the insecticide suspended, when it was to be used, as shown in the figure) was lowered into the flask and the rubber stopper pushed down tightly. This could be accomplished with but very little interchange of air taking place in the flask, so that solutions of the barium hydrate set away in this manner as checks

FIG. 2. A simple arrangement for obtaining the CO_2 output of insects under the influence of certain volatile insecticides.

(containing no insect) could be kept for days without any appreciable precipitate appearing.

The method of titrating with $\frac{N}{10}$ sulphuric acid has already been described (page 13) and the plan given there has been followed in all similar estimations.

In one set of experiments several beetles were taken from food at the same time; part of them were used in the air alone, and the rest were used, at the same time, under the same conditions except that they were treated with the insecticide. Grasshoppers were also used in a similar manner.

The method of recording and figuring the result of an experiment may be illustrated by a single example. Some of the results are then given in tabulated form.

EXAMPLE.

One *Passalus cornutus* was confined with 0.6 c. c. of gasoline on the absorbent cloth.

Used 50 c. c. $Ba(OH)_2$ stock-solution, equal to 6.7 c. c. $\frac{N}{10}$ Sulphuric acid.
Temperature, 72° F.
Began 2:45 p. m., Wednesday.
Ended 8:45 a. m., Thursday. Time, 18 hrs.
Wt. of beetle at beginning, 1.1485 grms.
Wt. of beetle at end, 0.9515 grms.
At the end, cage quickly removed; flask stoppered again and left 20 minutes before titrating.

50 c. c. $Ba(OH)_2$ then required only 5 c. c. $\frac{N}{10}$ acid. 6.7 — 5 = 1.7 c. c. $\frac{N}{10}$, or 0.17 c. c. normal CO_2 that had been given off by the insects.

1 c. c. of normal CO_2 = 0.022 grms. of CO_2; 0.17 c. c. of normal CO_2 = 0.00374 grms. CO_2 given off in 18 hrs.

100 grms. of beetle $= \dfrac{100 \times 0.00374}{0.9515 \times 18} = 0.0207$ grms. of CO_2 or 10.35 c. c. CO_2 at 0° C. and 760 m. m. Mercury.

TABLE III A.

Effect of certain insecticides upon CO_2 excretion.

(Different specimens—treated and untreated—other conditions the same).

No Specimens.	Temp.	Insecticide.	Time (hours).	Total CO_2.	CO_2 per 100 grms. of insects per hour.
1 Schistocerca americana.	74° F.	None.	22	0.00946 grms. or 4.73 c. c.	0.0342 grms. or 17.1 c.c.
1 same species.	Same.	Two drops of kerosene on abdomen.	Same.	0.01012 grms. or 5.06 c.c.	0.0362 grms. or 18.1 c.c.
1 same species.	Same.	Kerosene in all spiracles on one side of body.	Same.	0.00968 grms. or 4.84 c.c.	0.0346 grms. or 17.3 c.c.
2 same species.	Same.	Dipped in kerosene until apparently dead throughout the experiment.	Same.	0.00792 grms. or 3.96 c.c.	0.0158 grms. or 7.9 c.c
1 Passalus cornutus.	72° F.	None.	18	0.00198 grms. or 0.99 c.c.	0.0115 grms. or 5.75 c.c.
1 Passalus cornutus.	Same.	Vapor from 0.7 c.c. of kerosene on the absorbent cloth.	Same.	0.00374 grms. or 1.87 c.c.	0.0207 grms. or 10.35 c.c.
1 Passalus cornutus.	Same.	Vapor from 0.6 c.c. of gasoline on the absorbent cloth.	Same.	0.0055 grms. or 2.75 c.c.	0.032 grms. or 16.0 c.c.
1 Passalus cornutus.	72° F.	0.015 grms. of Pyrethrum suspended under the insect cage.	23	0.0052 grms. or 2.6 c.c.	0.0228 grms. or 11.1 c.c.
1 Passalus cornutus.	Same.	None.	20	0.00506 grms. or 2.5 c.c.	0.0133 grms. or 6.65 cc.
1 White-faced hornet.		None.	20	0.00528 grms. or 2.64 c.c.	0.064 grms. or 32.0 c.c.
Same specimen.		Vapor from 0.5 c.c. of gasoline on absorbent cloth.	16	0.0055 grms. or 2.75 c.c.	0.103 grms. or 51.5 c.c.

In other experiments certain beetles were tried in air. Then the same beetles were used again under the influence of the insecticide, with conditions of temperature, moisture, etc., similar to those of the former trials. Moreover, in order to see if the same results would obtain if unrespired air should continually pass through the vessel containing the insects, the apparatus represented in Fig. 3 was used. In this

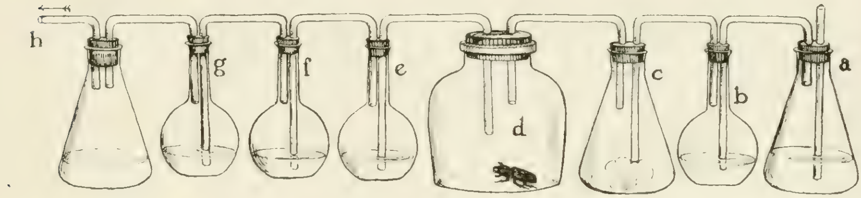

FIG. 3. Another arrangement for finding the CO_2 output of insects under the influence of volatile insecticides.

figure, the arrow represents the direction in which air was drawn by means of an aspirating filter pump connected at "h." An alkaline wash-flask for taking carbon dioxide out of the incoming air is shown at "a." Flask "b" contained a weak barium hydrate wash, and into "c" the absorbent cloth with the insecticide was placed when the effect of its vapors upon carbon dioxide excretion was to be studied. Flasks "e," "f," and "g" contained measured amounts of the standard barium hydrate. In these three flasks all the carbon dioxide which came from the respiration chamber "d" was caught. Care was taken to start the aspirating pump, after connecting up the apparatus and thus free the latter entirely of carbon dioxide before introducing the standard barium hydrate just previous to the experiment. Air was then kept bubbling slowly during the experiment; but a few minutes before the end, a rapid stream of air was started in order that all carbon dioxide might be carried from the respiration chamber. Table III B. gives results of three experiments carried out in this manner, using the same beetle.

TABLE III B.

CO_2 excreted by a beetle before and after treatment with gasoline vapor.

(See apparatus, Fig. 3.)

No. specimens.	Temp.	Insecticide.	Time (hours.)	Total CO_2.	CO_2 per 100 grms. of insects per hour.
1 Passalus cornutus.	72° F.	None.	8	0.00176 grms. or 0.88 c.c.	0.0225 grms. or 11.25 c.c.
Same beetle.	Same.	Vapor carried from 2 c.c. of gasoline in flask "C"	8	0.00286 grms. or 1.43 c.c.	0.036 grms. or 18.0 c.c.
Same beetle, two days later, nearly dead—having never recovered, in air.			16	0.0022 grms. or 1.1 c.c.	0.0153 grms. or 7.65 c.c.

An examination of Tables III A. and B. will show that where the insecticides were used in small amounts (either when the liquids were applied as such, or in the vapor form only) the rate of excreting carbon dioxide was increased. Even when the insects were partly stupefied the rate of giving off carbon dioxide might remain, for a time, higher than the normal in pure air. Note that a grasshopper, with all the spiracles on one side of the body plugged, gave off, in spite of that, as much carbon dioxide as was usually excreted in pure air when all spiracles were free. Large amounts of the liquids or of the vapors, when sufficient to bring the insect near death, caused a decided reduction in the rate of excreting carbon dioxide. In later respiration experiments it was found that hydrocyanic acid gas, the vapor of To-bakine, and the vapor of carbon disulphide produced very similar effects—except that small amounts of these insecticides did not cause nearly so large an increase in the excretion rate of carbon dioxide as did gasoline.

When using the aspirating pump method, in no case did any precipitate appear in the wash flask "b." Also, an experiment was run for eight hours with 2 c. c. of gasoline in flask "C" (no beetle in the respiration chamber) in order to find whether any carbon dioxide was given off from the gasoline or whether the vapor passing with the air through the barium hydrate solution interfered in any way with its titration. At the end of that time titrations were made, and the amount of $\frac{N}{10}$ acid required was within 0.05 c. c. of the required amount for the standard solutions—a difference within the limit of error in manipulation. Therefore, all carbon dioxide caught in the experiments with insects must have come from the insects, alone.

It should be stated further, that the beetles used for the experiments recorded in Table III A. were all taken from the same lot. The beetle used in the experiment recorded in Table III B. was taken from a fresh lot of very active specimens just collected. Different lots of beetles varied in their vitality and activity—specimens in the same lot even varied somewhat. But it is believed that the experiments were such as to leave no doubt as to the effects, as they are stated above, of the insecticides used.

EFFECT OF CERTAIN GASES AND VAPORS UPON THE RESPIRATORY QUOTIENT.

The influence of the contact insecticides studied upon the rate of carbon dioxide excretion made perfectly plain the desirability and importance of determining the effect of these insecticides upon the rate of oxygen absorbed by the insects during the same period of time. The one determination might serve as a valuable check upon the other; but more than that, it would make possible a study of the effects of an insecticide upon the respiratory quotient of an insect under varying conditions of amount or length of time the agent were used. In other words, a comparison could be made between the ratio of carbon dioxide given off to oxygen absorbed by an insect in air, and the corresponding ratio made by the same insect under the influence of an insecticide—other conditions being as nearly as possible the same. Such a comparison would be of value, of course, only if the respiratory quotient in air were a practically constant quantity for the insect, under controlled conditions—as has been found to be the case for higher animals.

Should the insecticide, then, cause an increase or a decrease in the carbon dioxide excretion, and should the oxygen absorption actually change in like proportion, the respiratory quotient would be found to remain constant—i. e., just as it had been in pure air. On the other hand, if either rate increased or decreased in value faster than the other, it would follow that the necessary change appearing in the respiratory quotient would show that condition.

The small size of insects and their peculiar mode of respiration through many stigmata made it impossible to collect expired air alone (un-mixed with any other) for analysis. Besides, a method was required which would permit the oxygen used and the carbon dioxide given off by the insect to be accurately estimated even when a volatile insecticide was present. (For, it must be remembered that all these contact insecticides given in the list, are more or less volatile). The carbon dioxide might be estimated from absorptions made with a standard solution of barium hydrate (an extremely accurate means already described) but the oxygen would have to be estimated volumetically. Absorption of oxygen by phosphorus or by potassium pyrogallate seemed to be the most promising, in this connection, of the different methods recommended by gas analysts.

The following method for obtaining the respiratory quotient was tried first:

An insect respiration-chamber was connected up in a circuit between a series of standard barium hydrate flasks and the air chambers of two vessels containing mercury with an air-space above the mercury in each. Connections were made in such a manner that by raising or lowering one of these mercury vessels every forty to sixty minutes, the mercury would run from one vessel to the other and pump the air very slowly through the respiration chamber, thence through the barium hydrate flasks, back into the air space of the bottle which the mercury was leaving. This circulation could be repeated over and over. In that way, the carbon dioxide was caught and could be determined by titration at the end of the experiment. Before the standard barium hydrate was introduced, the mercury pump was started and the air in the apparatus made to circulate through a carbon dioxide filter until entirely free from that gas. Also, arrangements were made so that samples of air could be taken from the apparatus for the estimation of the oxygen percentage at the beginning and at the end of the experiment. Knowing the volume of air at the beginning, it was therefore possible to determine how much oxygen had been taken up during the experiment. Very good constant results in carbon dioxide estimation were obtained with this apparatus, but the oxygen estimations varied. Rubber tube connections were necessary in part of the apparatus and they seemed to permit some diffusion—especially in case the vapors of an insecticide like gasoline were present.

The above method had some good points and might have been improved to reasonable efficiency for pure air experiments. Its practice was discontinued, however, because it did not seem well adapted to the use of insecticide vapors or to the exact estimation of the oxygen used by the insect.

Further preliminary experiments soon showed that in studying the effects of such volatile insecticides as gasoline, kerosene and the like, it was desirable (if not necessary) to be able to estimate the vapor of the insecticide present. At least, it was necessary to be able to remove the vapor-fumes entirely before estimating the oxygen in order to get accurate results. As is well known, when phosphorus is being used, the presence of even a trace of the fumes of carbon disulphide,

gasoline and similar volatile oils will interfere with the absorption of oxygen—sometimes preventing the absorption entirely.

Having made sure that beetles and grasshoppers were able to extract most of the oxygen from a limited amount of air, even in the presence of the carbon dioxide given off from their bodies, it was decided to try out the method of confining insects in a certain amount of air for some given period—the carbon dioxide present, and the oxygen remaining, both being estimated volumetrically at the end of that period. Of course, the oxygen and carbon dioxide value of the air could be determined at the beginning of the experiment and thus the oxygen used and the carbon dioxide given off easily found.

Trials of this method soon proved that reasonably constant results could be obtained from insects even when the carbon dioxide content of the air confined with them had risen to six per cent or more. In actual tests of effects of insecticide vapors, however, the percentage of carbon dioxide was never allowed to run so high.

Accurate measurements of the air samples to be used in the gas-analyses were difficult to obtain. Since the interval between the measurements of air samples for analysis at the beginning and at the end of a series of experiments on an insect was often one or two days it was necessary to reduce all measurements to O° C. and 760 m. m. mercury pressure. A simple compensation burette was sought, therefore, which would enable this reduced reading to be made directly, without the need of taking the actual reading of the thermometer and barometer and computing every time a measurement was made.

No complete outfit that was simple, conveniently adapted to this special work and at the same time sufficiently accurate, could be found on the market. But gradually, as the conditions to be met with became better understood, fairly simple apparatus for determining the respiratory quotient of insects was devised. A brief description of this apparatus and of its manipulation is necessary. The principal pieces of the entire outfit may be described under three headings: (1) respiration and gas-containers, for confining insects to be studied, transferring gases, etc.; (2) a measuring-compensating gas-burette outfit, used for taking accurate direct measurements of gases reduced to O° C. and 760 m. m. pressure; (3) various gas pipettes in which absorptions of different gases could be made during an analysis of any air-sample.

The form of *respiration container* finally designed is represented by "A" Fig. 7, page 60. It was made of strong, clear glass. At the top of the container was a two-way gas-tight glass stop-cock and at the lower part, a wide mouth. One outlet of the gas-cock was surrounded by a thimble device marked "th" which consisted of a rubber stopper "S," a doubleweight rubber connecting-tube "r," and a wider glass tube (a little longer than "r") that formed the thimble "th." This device enabled pure gas samples to be transferred under either mercury or water seal.

Insects were confined in the air of the container above mercury. An aspirating bottle containing mercury was connected to the lower mouth through a rubber stopper. About the wide neck, above the mouth of the container, was a metal band bearing hooks by which the rubber stopper could be securely fastened. The opening closed by the stopper was large enough so that insects could be introduced or the container cleaned readily. When in use, the latter stood in a heavy glass jar of suitable height where it could be held in an upright

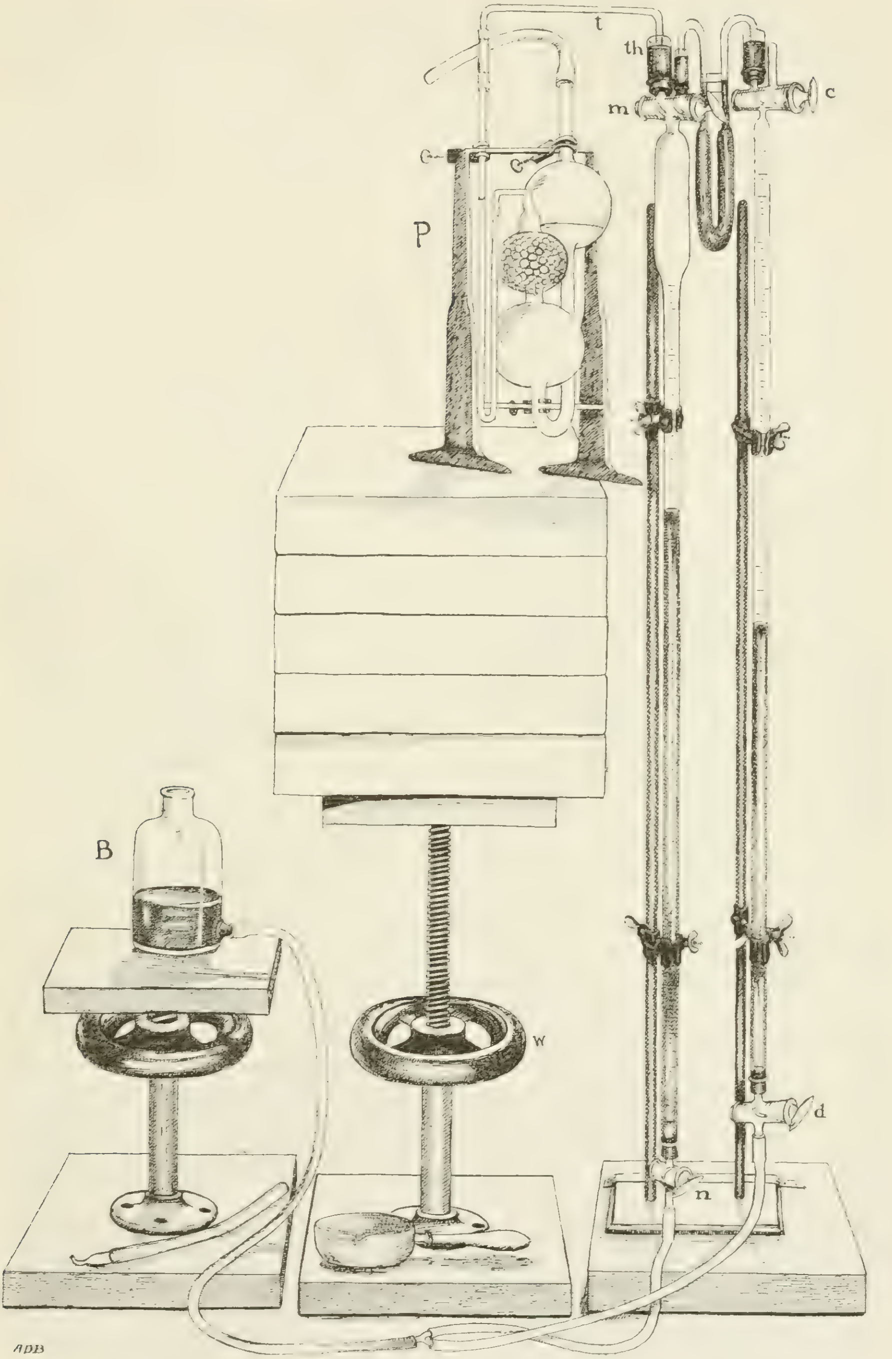

FIG. 4. Measuring-compensating burette, used in obtaining the volume-equivalent of gases at 0° C. and 760 m. m. mercury pressure. "M" = measuring burette. "C" = compensating burette. "P" = Hempel gas pipette. "B" = mercury aspirating bottle.

position by cloth pads. Thus any little overflow of mercury that might occur in making transfers of gas samples was caught safely in the supporting jar. Three sizes of the containers were used, viz. 250 c. c., 500 c. c., and 900 c. c. capacity. The larger size served mostly in preparing large stock supplies of air or of "air and insecticide vapor" to be used in the respiration experiments. Mercury is so bouyant that insects, (such as grasshoppers and beetles) rested entirely on the surface, scarcely making a dent in it.

The *measuring-compensating burette* outfit is represented in Fig. 4 along with one form of gas pipette used. Two gas burettes "M" and "C" were supported side by side and connected through adjacent outlets of the heavy two-way cocks at the top with the equal arms of a mercury manometer. The shape of the manometer that worked best is well represented in the figure. It was made of heavy clear glass. The lower, wider portion had a tube diameter of 3 millimeters. The bore of the narrower upper arms was 1 m. m., and they stood 1 cm. apart. At the back of these arms was pasted a scale. The whole manometer was 16 cm. high—the lower, wide portion being 7 centimeters. The two-way cocks were long, with almost parallel sides and were carefully ground to make them gas-tight. The free outlet tube of "M" was fitted with the thimble device already described in connection with the respiration container. The measuring burette "M" was 85 cm. long and was graduated to 100 cubic centimeters. A bulbous portion at the top, of 50 c. c. capacity, permitted the remainder of this burette to be of such diameter that graduations to 0.05 of 1 c. c. could be easily read with the naked eye. "C" was graduated to 80 cubic centimeters. (Another outfit was obtained exactly like the one figured except that its measuring burette had no bulb at the top and therefore small amounts of gases could be measured. This was not often needed however.)

The cocks at the lower ends of the burettes were fastened in securely by means of long rubber stoppers and these could be removed in case it became necessary to clean the burettes with a brush. The lower cocks were connected through a U-tube with a single aspirating mercury bottle, "B." The tube connections were of such length that the mercury-bottle might be lifted a few inches above the tops of the burettes.

The screw-supports represented in the figure were a very satisfactory and necessary part of the outfit. The tops of these supports (25 cm. square) could be steadily raised or lowered by simply turning wheel, "w." As already mentioned the compensating burette would enable gases to be measured in burette "M"—the volume equivalent to that at 0° C. and 760 m. m. pressure being given directly. Before the apparatus could be used in that way, however, it was necessary to place a certain amount of air in the compensating tube under the proper pressure.

A calculation was made to determine the volume of 50 c. c. of dry air, at 0° C. and 760 m. m. pressure, when measured moist at the temperature of the laboratory and the prevailing barometric pressure. This was done from the equation—

$$V = \frac{V_0 \times 760 \times (273 + t)}{(B - W) \times 273}.$$

In this equation, t = temperature of room, Centegrade; B = prevailing barometric pressure; W = tension of aqueous vapor at $t°$ C; V = volume under the prevailing conditions; and V_0 = the reduced volume at O° C and 760 m. m. mercury pressure.

The values of "t" and "B" could be read from the thermometer and barometer. The value of "W" is given in tables of water vapor tension; and since "V_0" was taken as 50 c. c., the equation could be solved for "V." Suppose it was found that 50 c. c. (dry air, O° C. and 760 m. m.) would occupy 58 c. c. under the prevailing laboratory room conditions. The apparatus would then be prepared for use as follows: The two-way cocks "m" and "c" became alternately opened to the outside and then into the manometer arms until the air in the "arms" was at atmospheric pressure and the mercury in the two arms stood at the same height as shown by the scale. Cock "m" was then closed and "c" opened to the outside. Cock "d" was opened and the mercury bottle, "B," manipulated until exactly 58 c. c. of air and a single drop of water had been drawn into "C" through the outlet tube of cock, "c." (The arm of the manometer connected with "C" contained 0.8 c. c. of air and that was taken into account in making the measurement.) This air was compressed to exactly 50 c. c. and "d" was again closed and left closed. After that, whatever the change in temperature or pressure the reduced volume of the air in "C" always equalled 50 cubic centimeters. Without going into further detail, it may be seen by a study of the figure how after any gas (saturated with moisture) was drawn into "M," the apparatus could be manipulated to balance the compression of that gas against the compression of the air in "C." The mercury manometer made it possible to do that accurately. If the temperature of the room in which the work was done remained constant or changed but slowly, the gas in "M" became measured under exactly the same conditions of temperature and pressure as the gas in "C." The reduced volume of the gas in "M" must therefore equal its volume at O° C. and 760 m. m. mercury pressure, since under the same conditions of temperature and pressure volumes of gases are proportional.

Care was necessary in manipulating the apparatus, at first, to prevent the mercury in the manometer from being forced over into one of the burettes. If that happened, the manometer could again be filled to the proper height by raising the mercury in one of the burettes until it poured over through the narrow manometer-arm. Then the required amount of air for "C" must be again calculated.

Moreover, observation tests were necessary to make sure that the connections remained gas tight. It was found necessary to keep the manometer connections under mercury seal. The work was done in a basement room where any change in temperature came very slowly. If the hand was laid upon one burette or a gas-container for a moment, it was necessary to wait until the temperature again became adjusted before taking any gas measurement. When the proper care had been observed, burette ""C" would stand the test for two to three weeks without the necessity of being refilled; and after one became accustomed to the apparatus, accidents scarcely ever occurred.

The *gas pipettes* used were the various forms of Hempel pipettes

which are on the market. Two of these forms are represented in Figs. 4 and 5 at "P." The use of various Hempel pipettes is described in most recent books on gas analysis, and their manipulation in connection with this work may be briefly referred to later in the paper.

In using this apparatus to determine the normal respiration of insect species the percentages of nitrogen, oxygen and carbon dioxide were first determined for the air to be used. An air-sample of anywhere between 100 c. c. and 75 c. c. was measured by the measuring-compensating burette. Water was placed in the thimble "th" (see Fig. 4.) until the rubber connecting tube was full. The solution[1] in a

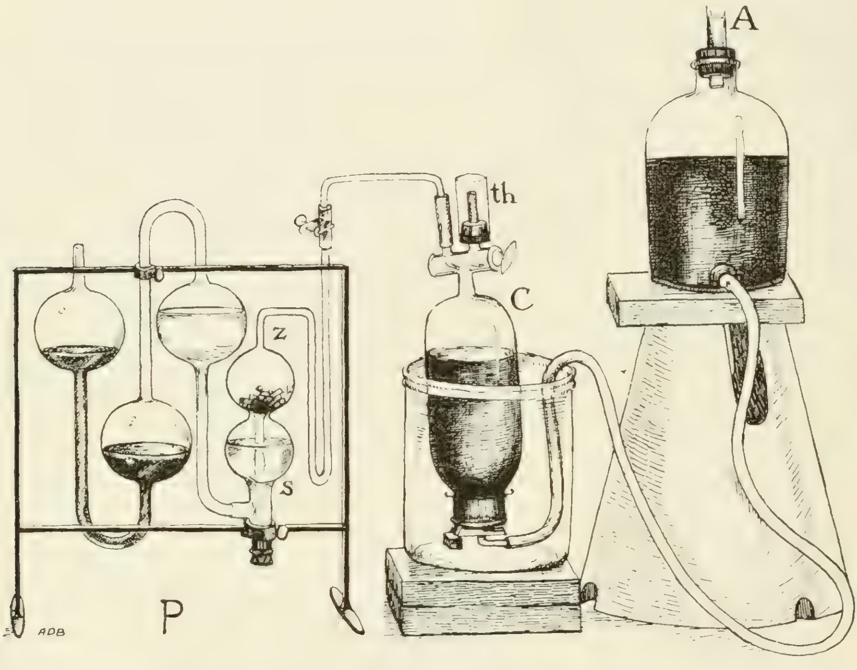

FIG. 5. Apparatus used in obtaining small amounts of hydrogen or of nitrogen entirely free from oxygen. "C" = gas container, same form as used for a respiration container.

potash pipette was then forced over slowly through the capillary transfer tube "t" until a drop was just ready to fall into "th." The free end of "t" was then forced down firmly into the rubber connecting tube. In this manner connections could be made so that all undesired air was excluded and only the measured air was transferred. When the carbon dioxide had been absorbed, the mercury "M" was lowered slowly until, finally, the potash solution was drawn over in "t" just into the top of the connection-tube within "th," when "m" was closed. Tests showed that all of a gas-sample, to within 0.05 c. c. could be returned thus without drawing any of the potash solution[2] into "M." The gas was then measured as before; the difference between this reading and the first being the volume of carbon dioxide present.

1. A solution of c. p. KOH of the strength recommended by Hempel was used.

2. As a precaution, however, the measuring burette (M) was washed out before the next new estimation of CO_2 was begun.

The potash pipette was disconnected. The thimble and connecting tube were thoroughly washed out. Then, the phosphorus pipette was connected up so that the gas transfer for oxygen absorption was made in a similar way to the one just described. After this absorption was complete, the remaining nitrogen was measured. The difference between this and the last previous gas volume gave the cubic centimeters of oxygen absorbed. Knowing the volume of the gas-sample at the beginning, of course the percentage of each gas could be calculated. With proper care, the results were so accurate that three successive estimates of the oxygen percentage in any pure sample could be made with a variation less than one-tenth of one per cent.

The insect was then placed in a respiration container; the stopper was inserted and mercury allowed to flow from the aspirator-bottle until the heavy fluid entirely filled the rubber connecting tube, and floated the insect up in the container. After that the latter could be set in place in its glass supporting jar. The aspirator was then raised until almost all the air was forced out of the container, the insect being brought as near the top as possible without injury. Some of the air sample to be used in the experiment was then drawn in with the insect and, after a moment, expelled through the other outlet of the two-way cock. This process was quickly repeated two or three times, when the required amount of air plus enough for an extra estimation could be drawn into the container. This extra volume was quickly transferred to the measuring burette for a final check estimation, and the respiration experiment was started. At the end of a certain length of time, the gases with the insect were estimated again by the method already described. Thus the percentage, or the actual amount of carbon dioxide given off and of oxygen used during that time might be found. The *percentage* found was very accurate since all measurements of gases for estimation could be made to within 0.05 of a cubic centimeter. The amount of air placed with the insect, however, could not be measured so accurately because of the wide diameter of the container. On that account, therefore, the respiratory quotient was usually found from the percentage values of carbon dioxide given off and of oxygen used by the insect.

A single example will illustrate the manner of recording measurements and estimating results:

First, suppose the air sample taken from a respiration chamber at the beginning of an experiment gave 20.69% oxygen, 79.24% nitrogen and 0.05% carbon dioxide.

Wt. of two specimens of *P. cornutus* used = 3.287 grms.
Exp. began 8 p. m., March 8, 1910—Room Temp. 22° C.
Used about 200 c. c. air in all.
Exp. ended 8 a. m., March 9, 1910.—Time, 12 hours.
Took, of the respired air, for estimation:

82.8 c. c.
80.2 c. c. after KOH pipette.

2.6 c. c. = 3.14% CO_2
66.75 after Phosphorus pipette = 80.61%N.

13.45 c. c. = 16.24%O_2

A second sample tried out as soon as possible after this checked closely, showing just a little more carbon dioxide and a little less oxygen (0.2%)—as was to be expected.

It will be noticed at once that the percentage of nitrogen was higher at the end of the experiment than at the beginning. As is apparent also, the oxygen used was greater than the carbon dioxide given off. Now, this latter fact would decrease the volume of gas with the insects; and that decrease, alone, would cause the percentage of nitrogen to rise, if the cubic centimeters of that gas present remained the same. (As will be proven later, the amount of nitrogen is not appreciably diminished or increased by an insect during respiration.) Indeed, it must be evident that a decrease in volume due to an absorption of one or more components in a gas-mixture must be accompanied by a proportional increase in the percentage of all other components. If, for a single gas component then, the ratio of increase be found, it would be known for all the rest. Since, in air confined with respiring insects, the volume of nitrogen remains unchanged, the ratio of its percentage at the end of the experiment to its percentage at the beginning must be the desired ratio. To find the amount of each component gas in the larger volume of air at the beginning necessary to make a certain percentage of nitrogen at the diminished volume, therefore, one has only to multiply the nitrogen ratio mentioned by the per cent of each component gas present in the gas mixture at the beginning. The difference between the volumes of component gases so found and the per cents (i. e., volumes per 100 c. c.) of the same gases at the end of the experiment must equal the actual loss or gain, per 100 c. c. of respired air, of each component gas—due to its absorption or excretion by the insect.

Thus in the experiment recorded above, the nitrogen ratio would be $\frac{80.61}{79.24}$; and for 100 c. c. of the respired air, the larger volume of that air at the beginning contained:

$$CO_2 = 0.05 \times \frac{80.61}{79.24} = 0.05 \text{ c. c.}$$

$$O_2 = 20.69 \times \frac{80.61}{79.24} = 21.04 \text{ c. c.}$$

CO_2 excreted per 100 c. c. of respired air = 3.14—0.05 = 3.09 c. c. (gain in CO_2).
The O_2 absorbed per 100 c. c. of respired air = 21.04—16.24 = 4.8 (loss in O_2).

$$\text{Respiratory quotient} = \frac{CO_2}{O_2} = \frac{3.09}{4.80} = 0.64.$$

Table IV gives the results of some respiration experiments carried out by the method just described with a few species of insects in air. Moist air at temperatures between 20° and 24° C. was used.

TABLE IV.

Respiration, and $\frac{CO_2}{O_2}$ *of insects in air.*

No. Exp.	Insect.	Air.	O_2 used.	CO_2 given off.	Respiratory-quotient.	Time in hours.
1	4 specimens of P. Cornutus. Wt.=6.55 grms	200 c.c.	35.54 c.c. Total.	25.82 c.c. Total.	0.72	14
2	Same specimens as No. 1. Wt.=5.95 grms	175 c.c.	5.42 c.c. Total.	4.25 c.c. Total.	0.78	2½
3	4 P. cornutus. Wt.=6.42 grms	200 c.c.	3.8 c.c. Total.	2.6 c.c. Total.	0.68	
4	Same as No. 3	250 c.c.	42.06 c.c. Total.	29.37 c.c. Total.	0.69	14¾
5	Rose aphids, 0.125 grms	200 c.c.	3.58 c.c. Total.	2.58 c.c. Total.	0.72	21½
6	6 Melanoplus femoratus, about 5 grms	76.6c.c.	2.25 c.c. Total.	1.75 c.c. Total.	0.77	½
7	2 Passalus cornutus, 3.16 grms	200 c.c.	5.95%	4.4%	0.73	16
8	1 P. cornutus, 1.6 grms	170 c.c.	2.5%	1.56%	0.63	8¾
9	Same as No. 8	170 c.c.	2.96%	2.02%	0.68	12⅓
10	4 P. cornutus, 6.4 grms	300 c.c.	5.43%	3.78%	0.69	11
11	Same as No. 10	Air with 15.6% O_2 and 3.78% CO_2.	15.42%	11.6%	0.75	24

Table IV gives the result of some respiration experiments carried out by the method just described with a few species of insects in air. Moist air at temperatures between 20° and 24° C. was used.

The results tabulated in IV represent great variation in the amounts of carbon dioxide and oxygen present at the end of the experiments. It will be seen that these variations did not affect the value of the respiratory quotient very much. In record No. 1, only about 3% of oxygen remained at the end of the experiment. When however, the oxygen percentage became less than one, the respiratory quotient was found to rise in value. This is illustrated in records No. 10 and No. 11. Note that in none of the following experiments testing the effect of insecticides was the percentage of oxygen allowed to run anything like that low.

After specimens of *P. cornutus* were kept in the insectary some time, even under the best care, with food, their vitality lowered and the value of the respiratory-quotient diminished a little. Results of experiments No. 8 and No. 9 are of this kind. During an experiment, insects lose in weight a small amount (see Nos. 1 and 2 Table IV) due to excreta and water vapor thrown off.

EFFECT OF GASOLINE AND KEROSENE VAPORS UPON $\frac{CO_2}{O_2}$

In studying the effect of insecticide vapors upon the respiratory quotient of insects, it was the aim to eliminate from consideration all other factors by keeping them the same through both parts of the experiment. Thus, the respiratory quotient was first found for an

insect or group of insects in pure air under certain conditions of temperature, moisture, etc., and then it was found for the same insects under the same conditions, as nearly as possible, but with the vapor of the insecticide present in the air respired. Gasoline and kerosene vapors were used first. A stock supply of gasoline or kerosene air was prepared in one of the large containers. Enough of this stock supply of vapor-air for several estimations would be drawn into a container with the insects. By connecting the respiration container with a similar gas-container through a capillary transfer tube, the gas could be passed back and forth until thoroughly diffused; then a sufficient amount could be kept in the gas-container for two or three estimations. In this way, checks of the percentage values of carbon dioxide, oxygen, gasoline or kerosene vapor, and nitrogen present at the beginning of the experiment might be obtained. The component gases were estimated at the beginning and at the end of each experiment in a certain order. Between 75 and 100 c. c. of the vapor-air was measured off in the measuring-compensating burette. The carbon dioxide was absorbed with a potash pipette in which some of the vapor-air to be absorbed had been previously standing, and the remaining gas was again measured. The kerosene or gasoline-vapor was next destroyed in a fuming sulphuric acid pipette; several minutes were required to do this completely. With a potash pipette, used only for that purpose, the fumes of the sulphuric acid were absorbed and the gas was again measured. Finally, the oxygen was absorbed with either a phosphorus or a potassium pyrogallate pipette—phosphorus was used mostly. The remaining gas was the nitrogen present.

One-tenth cubic centimeter of water was used in the measuring burette above the mercury, and the burette was washed out after each complete gas estimation. The water was necessary in order to insure the air being measured moist after treatment with the sulphuric acid. By using every precaution, after much practice, the possible error could be kept below 0.2% as shown by duplicate estimations. The greatest source of error came in using the fuming sulphuric acid.

The record for a single estimation of respired gasoline-air is given here.

Took 82.4 c. c. respired gasoline-air.
77.05 after KOH pipette.
5.35 c. c. CO_2 = 6.49% CO_2.
69.65 after H_2SO_4 and KOH pipettes.
7.4 c. c. gasoline vapor = 8.98% gasoline vapor.
59.3 — after Phosphorous pipette = 71.96% nitrogen.

10.35 c. c. O_2 = 12.56% oxygen.

At the beginning, estimations gave 0.04% CO_2, 9.22% gasoline, 71.79% nitrogen and 18.95% oxygen.

$$\text{Nitrogen ratio} = \frac{71.96}{71.79}.$$

$$0.04 \times \frac{71.96}{71.79} = 0.04 \text{ c. c. } CO_2\text{, at beginning, to each 100 c. c. respired air.}$$

$$9.22 \times \frac{71.96}{71.79} = 9.24 \text{ c. c. gasoline vapor, at beginning, to each 100 c. c. respired air.}$$

$$18.95 \times \frac{71.96}{71.79} = 18.99 \text{ c. c. oxygen, at beginning to each 100 c. c. respired air.}$$

6.49 — 0.04 = 6.45 c. c., gain in CO_2 for each 100 c. c. respired air.
9.24 — 8.98 = 0.26 c. c., loss in gasoline-vapor for each 100 c. c. respired air.
18.99 — 12.56 = 6.43 c. c., loss in O_2 for each 100 c. c. respired air.

$$\frac{CO_2}{O_2} = \frac{6.45}{6.43} = 1.003$$

Nine sets of experiments were carried out to determine the influence of kerosene and gasoline vapors in air upon the respiratory quotient of *P. cornutus*. Five of these sets are recorded in Table V, (page 36).

It will be seen that the percentage of oxygen present in the vapor-air respired was still comparatively high at the end of the experiments. A quotient of 0.89 as given in set No. 5 was the largest obtained when using kerosene vapor. None in any set fell below the average ratio for the beetles in air. In case of the other experiments with gasoline vapor, the results ran very similar to those recorded, except in two instances. All quotients influenced by the latter vapor are higher than those obtained when using kerosene vapor. Note also that when the insects were deepest under the influence of the vapor and nearly dead, the respiratory ratio was highest. It was in testing out this last point that the two exceptions mentioned occurred. Two estimations of oxygen made for a period when the beetles were nearly dead, indicated that no oxygen was absorbed while a rise of 0.43% of carbon dioxide was found. In fact, the percentage of oxygen at the end seemed slightly higher than at the beginning of the experiment, but that might be attributed to experimental error. Kerosene did not give a very high percentage of vapor at the temperature used and it did not bring the insects deeply under its influence rapidly as was the case with the more volatile gasoline.

INFLUENCE OF HYDROCYANIC ACID IN AIR UPON THE $\frac{CO_2}{O_2}$ OF PASSALUS CORNUTUS.

The influence of hydrocyanic acid gas in air upon the respiratory quotient of *Passalus cornutus* was next studied. Enough air-hydrocyanic acid mixture was confined with the insects to make at least two complete estimations—one at the beginning and one at the end of the experiment.

About 75 c. c. of the air-mixture to be estimated was drawn off and measured accurately by the use of the compensating burette. This volume (V) was for the estimation of the hydrocyanic acid alone. It was passed slowly into a small amount of potassium hydrate solution in a flask, which was set aside. As quickly as possible another measure (V′) of 75 to 80 c. c. of the same mixture was made. The hydrocyanic acid gas and carbon dioxide present in this volume were absorbed in a potash pipette and the percentage of the two gases, together, determined. Oxygen was absorbed from the remaining gas in a phosphorus pipette and its percentage, as also that of the nitrogen, was found in the manner described for former estimations.

Silver nitrate was afterward added to the alkaline solution that had been set aside; the contents of the flask were then acidified slightly with nitric acid and filtered. The filtrate was dried, ignited in a por-

TABLE V.

Influence of Kerosene and Gasoline Vapors upon $\frac{CO_2}{O_2}$.

	Specimens.	Treatment.	Temp.	Resp. period. (hours.)	$\frac{CO_2}{O_2}$	Insecticide, vapor present. At beginning.	Insecticide, vapor present. At end.	O_2 at the end.	Condition.
1	4 Passalus cornutus, 6.55 grms	Air	22°C.	14	0.72	....	....	3.84%	Active.
1	Same beetle	Air	24°C.	2½	0.78	....	....	17.64%	Active.
1	Same beetle	Air—gasoline vapor	24.5°C.	8	0.89	9.24%	8.64%	14.52%	Alive, but no recovery.
2	2 P. cornutus, 3.28 grms	Air	22°C.	12	0.64	....	....	16.24%	Active.
2	Same beetles	Air—gasoline vapor	20.5°C.	5	1.00	10.04%	9.33%	17.55%	Just able to move slightly.
3	3 P. cornutus, 4.817 grms	Air	25°C.	3	0.58	....	....	17.23%	Active.
3	Same beetles	Air—gasoline vapor	26.5°C.	5	0.69	10.09%	9.49%	11.31%	Able to move a little.
3	Same beetles	Air—gasoline vapor	25.5°C.	7⅔	1.003	9.22%	8.98%	12.56%	Heart-beat scarcely evident.
3	Same beetles	Air—gasoline vapor	27.5°C.	10	2.01	9.8%	9.64%	17.03%	Died during this time.
3	Same beetles	Air	....	19	0.83	....	....	11.35%	Odor of decay.
4	1 P. cornutus, 2.11 grms	Air	20.5°C.	12	0.71	....	....	18.38%	Active.
4	Same beetle	Air—kerosene vapor	18°C.	21	0.72	0.58%	0.47%	17.3%	Heart beating only.
5	1 P. cornutus, 2.07 grms	Air	22.5°C.	24	0.79	....	....	17.52%	Active.
5	Same beetle	Air—kerosene vapor	20°C.	23	0.79	0.4%	0.18%	18.31%	Still active.
5	Same beetle	Air—kerosene vapor	....	12	0.89	0.3%	almost none.	20.11%	Could walk awkwardly a little.
5	Same beetle	Air	....	18½	0.70	....	....	18.26%	Weak, but still moving.

celain crucible, and the resulting globule of silver was weighed. For every atom of silver in the fused filtrate a molecule of hydrocyanic acid had been caught in the potassium hydrate flask at the beginning. One-fourth the weight of the silver, therefore, gave the weight of the hydrocyanic acid and from this weight its volume in the measured amount of air-mixture became known and consequently its percentage also. By subtracting this percentage from the combined percentage value of carbon dioxide and hydrocyanic acid already found, the value of the carbon dioxide present was given.

A source of error, which needed most attention in this method was due to the fact that hydrocyanic acid decomposes rapidly, forming certain solid bodies.* The percentage of acid-gas in the(V′) volume was certain, therefore, to be enough lower than in the (V) volume to introduce a fatal error in the carbon dioxide estimation unless certain precautions were observed. Experiments showed that in the case of air containing 10.5% of hydrocyanic acid, the decrease in the acid might be as high as 1.1% in 15 minutes. But the *rate* of decrease fell rapidly as the percentage of the gas became lowered; so that in air containing 2.5% hydrocyanic acid, the fall was only 0.16% in 30 minutes. The tests were carried out under the ordinary light conditions of the laboratory.

At the best, about 10 to 12 minutes were required between the(V) and (V′) measurements. Moreover, high percentages of the poison gas were not necessary or useful in studying the effect of this gas upon respiration, since 0.8% in the respired air was sufficient to render *P. cornutus* motionless in 8 to 10 minutes. Even 0.01 of 1% rendered strong specimens of the beetle partly helpless for a time.

The hydrocyanic acid used in these experiments was made from pure potassium cyanide and sulphuric acid in a very small cup which was floated on the mercury within a gas container.

After a good deal of preliminary practice a series of eight sets of experiments were carried out by the above method using three or four specimens of *P. cornutus* at a time. In two of these, the amounts of the respiratory exchange were very small and approached the limit of accuracy so closely as to make the quotients found of doubtful value; e. g. $\frac{CO_2}{O_2} = \frac{0.15}{0.16}$. The other experiments, however, seemed to demonstrate that the influence of hydrocyanic acid (when present in amounts just sufficient to render the beetles helpless) was to increase, slightly, the value of the respiratory quotient. Most of the quotients influenced by this insecticide were only a little higher than those given by the same insects in air; the average was 0.3 higher. The largest quotient was $\frac{0.94}{0.73} = 1.28$ —— the quotient in air for the same specimens being $\frac{0.75}{1.08} = 0.69$.

EFFECT OF CARBON-DISULPHIDE VAPOR UPON $\frac{CO_2}{O_2}$ OF PASSALUS CORNUTUS.

A plan was worked out (in theory) for estimating the vapor of carbon disulphide, when present in air, by the combustion method—the two products of complete combustion could both be estimated

*A white cryst. powder was deposited in considerable amounts—probably ammonium oxalate and ammonium formate.

readily. Thus, the influence of this vapor upon the respiratory quotient might be studied in a manner similar to that described already for three other insecticides. A platinum wire heated in a suitable container of the air-vapor mixture was used to effect the combustion. The theory was good, but a series of experiments showed that it was apparently impossible to control the amount of vapor used so as to obtain satisfactory complete combustion. Always, some of the carbon of the burning vapor was deposited as a black soot instead of being completely burned to carbon dioxide. Besides, a terrific, uncontrolled explosion sometimes occurred. This plan, therefore, had to be given up. Neither could a satisfactory method be found for estimating both carbon dioxide and oxygen in the presence of carbon disulphide vapor.

One other method, however, seemed worthy of trial. It had been noticed in case of all the vapors whose influence upon the insects was decidedly anaesthetic or narcotic, that the effects were apt to continue for a long while after specimens were removed from the presence of the insecticide vapor. This was especially true of carbon disulphide and nicotine when beetles had been brought deeply under their influence. If specimens were treated with the right amounts of the vapor of either of these fluids they might lie for many hours as if dead—showing, perhaps, only a faint heart-beat at times or slight jerking movements of the antennae and feet.

Recourse was therefore had, in the case of these two insecticides, to the following method. First, the respiratory quotient was obtained for two specimens of *P. cornutus* in air under controlled conditions. Then the same specimens were treated with the vapors of the insecticide until nearly dead, after which they are allowed to lie in the open air for several minutes until the odor of the insecticide had disappeared. Finally, they were placed in a respiration chamber again, in pure air. Enough air was used so that, after about a half hour, a sample could be taken for analysis. The respiration period was counted from the time the sample was obtained—the percentages of oxygen, carbon dioxide, and nitrogen found by its analysis being taken as the beginning values of those component gases. Thus, the estimation served at the same time as a check to show that no more of the insecticide vapor had been given off from the insects to interfere with oxygen estimations.

Obviously, in studying the effects of an insecticide vapor upon the respiratory quotient, the best way would be to have some of the vapor present in the respired air all through the experiment —the percentage of the vapor being accurately determined—as was done when using gasoline, kerosene, and hydrocyanic acid. But as has already been stated, the latter method could not be used successfully with the two fluids in question. As it proved out, the method used *did* give some interesting and instructive results. They are, therefore, recorded here in Table VI.

TABLE VI.

After-effects of CS_2 and To-bak-ine on $\frac{CO_2}{O_2}$ of Passalus cornutus.

Exp. No.	No. of Speci-mens.	$\frac{CO_2}{O_2}$ in air.	$\frac{CO_2}{O_2}$ after CS_2 vapor.	Resp. period in air (hours.)	Resp. period after CS_2 (hours.)	Condition after insecticide vapor had been used.
1	2	$\frac{2.48}{3.34}=0.74$	$\frac{0.47}{0.62}=0.75$	7½	8	No movement during the experiment. No heart-beat, and apparently dead.
2	2	$\frac{2.41}{3.21}=0.75$	$\frac{9.92}{13.15}=0.75$	7	15	Recovered enough to become rather active about the middle of the experiment period, but motionless and heart beating feebly at end.
3	2	$\frac{3.41}{4.76}=0.71$	$\frac{4.52}{4.97}=0.90$	8	12	Legs stiff; no signs of life at beginning except irregular heart-beats. Almost no recovery of motion.
4	2	$\frac{2.69}{3.63}=0.74$	$\frac{3.38}{5.15}=0.65$	6½	6½	Motionless, but legs not stiff. Heart beating. Both recovered somewhat. Legs of one could move quite freely. Neither became able to feed again.
5	2	$\frac{2.94}{4.64}=0.65$	$\frac{11.47}{14.94}=0.76$	7½	14¾	Only motion made was by antennae quivering at tips, at beginning. At end, one apparently dead. Heart beating slowly in the other.
6	2	$\frac{2.24}{3.09}=0.72$	$\frac{2.58}{2.84}=0.90$	6½	19½	Apparently lifeless throughout the experiment. But not the least signs of decay shown.
			$\frac{CO_2}{O_2}$ after vapor of To-bak-ine.		Resp. period. after To-bak-ine.	
7	2	$\frac{1.09}{1.66}=0.65$	$\frac{1.97}{2.92}=0.64$	2½	7	Sick and unable to stand from the effects of To-bak-ine vapor at first. (Very slight show of recovery.)
	Same.		$\frac{4.30}{6.39}=0.67$		14¼	One beetle had recovered, but little more. The other one had become more active.
8	2	$\frac{10.85}{14.6}=0.73$		17¼		
	Same.	$\frac{2.06}{2.94}=0.70$	$\frac{6.78}{9.58}=0.70$	4¼	16	Could only move the antennae and feet; quivering, at first. Able to walk at end.
9	2	$\frac{1.28}{2.28}=0.56$	$\frac{1.02}{1.65}=0.61$	4½	4¾	Deeply under. Antennae quivering; almost no recovery.
	Same.		$\frac{1.91}{3.13}=0.61$		12½	At the end of this time, only signs of life in the larger one was a slow heart-beat. Smaller one able to move antennae and legs.
10	2	$\frac{1.81}{2.41}=0.75$	$\frac{1.78}{2.61}=0.68$	5	4⅚	Very little recovery.
11	2	$\frac{2.48}{3.38}=0.70$	$\frac{6.56}{9.13}=0.71$	5⅔	18	These beetles were deeply under all the time. Heart-beat, and that only part of the time, shown at end.
	Same.		$\frac{0.36}{0.39}=0.90$		4⅙	

In these experiments, the respiratory quotients of the insects, after treatment with carbon disulphide vapor, averaged about 0.08 higher than those made for the insects in air; after treatment with To-bak-ine vapor the quotients averaged only about 0.01 higher.

In any case the insects most deeply affected by either of the insecticides, but yet not killed at the beginning, gave the highest respiratory quotients.

It will be seen from the table that the rate of the respiratory exchange was greatly lowered if specimens were deeply under the influence of carbon disulphide vapor. If they were only partially paralyzed by this vapor, however, the rate of the respiratory exchange might run as high or higher than in air (see No. 4.). Very little carbon disulphide vapor was required to render the insects helpless. On the other hand, beetles were not so easily rendered helpless by To-bak-ine; and when partially paralyzed, the rate of the respiratory exchange was lowered.

If found during a period of decided recovery from either of these insecticides, the respiratory quotient was never higher, but usually just a little lower than the normal for the same beetles in air.

EFFECT OF AMMONIA GAS ON $\frac{CO_2}{O_2}$ OF PASSALUS CORNUTUS.

In a preliminary study of the influence of ammonia gas upon the respiratory exchange of *P. cornutus*, it was soon found that, in the presence of enough of the gas to noticeably influence the action of the beetle, practically no carbon dioxide was given off; oxygen, however, was still taken up. Furthermore, it was learned that during the time beetles were confined with a certain volume of air-ammonia mixture, the percentage of ammonia gas kept decreasing provided the beetles remained alive) until finally no more was present in the air confined with them. Then, almost immediately as it seemed, carbon dioxide began to appear in the respired air.

It seemed as if the ammonia might be uniting with carbon dioxide produced by the insects and that the union, perhaps, was taking place within their bodies, since no solid compound formed by the two gases was to be seen on the mercury or on the sides of the container. If this surmise were true, it was evident that no true relation could be obtained between the carbon dioxide produced and the oxygen used under the influence of ammonia, unless the carbon dioxide fixed in this way could be liberated and estimated.

As is well known, ammonia and carbon dioxide will unite, in a water solution, to form ammonium bicarbonate. It seemed probable that the conditions within the insect body might be favorable for such a combination.

Now if ammonium bicarbonate is boiled in a water solution, it becomes broken up—the products, ammonia and carbon dioxide, both being driven off. This test was therefore tried with insects. Beetles that had been treated for several hours with ammonia were afterward dropped into boiling water and distilled, when *both* ammonia and carbon dioxide *did* appear in the distillate. If untreated beetles were distilled in boiling water a small amount of carbon dioxide but no ammonia was obtained.

Finally then, the following method for making the required determi-

nations of carbon dioxide and for obtaining other data necessary to show the influence of ammonia upon the respiratory quotient of the beetles, was worked out:

A group of three or four beetles was weighed and the respiratory quotient for the group in air was found in the usual manner. A stock preparation of ammonia-air, containing the desired percentage of ammonia for the experiment, was prepared in a large container. The group of beetles, having been left in fresh air for a time, was now placed in a respiration container. The mercury was forced up around them until all the air was expelled and a measured amount of the prepared ammonia-air was quickly drawn into the container with the insects. No carbon dioxide was in this air at the beginning, and the percentages of ammonia, oxygen, and nitrogen were determined. At the end of the experiment, the oxygen and nitrogen percentages were again determined as was also the percentages of carbon dioxide, or ammonia—only one of the latter gases would be present in decidedly measurable amounts in the respired air. For determining the percentages of the component gases, two samples of the respired air were taken. One sample of 70 to 80 cubic centimeters was passed into a measured quantity of standard barium hydrate solution and the carbon dioxide, if present, was then determined by the titration method already described. The other similar sample was first passed into a sulphuric acid pipette ($H_2\ S\ O_4$ of Sp. gr. 1.84 diluted one-half), then into a potash pipette and finally into a phosphorus pipette. Any ammonia present was absorbed by the sulphuric acid and its percentage could be found. Of course, measurements of the remaining gas were made after each absorption. Any carbon dioxide was taken up in the potash pipette. Besides, a check estimation of the latter gas, if present, had already been made by the barium hydrate method. The percentage of nitrogen and oxygen (also the per cent of oxygen used) could be figured out in the way described for former estimations of these gases.

All the gas contained with the insects at the end was measured. Since the volume of the air at the beginning and at the end was known, then, it was possible to determine the total amount of ammonia that had been taken up by the insects during the experiment, the total amount of oxygen used, and the total amount of free carbon dioxide (when present) in the respired air.

For determining the amount of carbon dioxide and ammonia that were retained within the beetles, the apparatus represented in Fig. 6 was used. In this apparatus, the large jar (j) was a carbon dioxide filter. Before the experiment was started, the apparatus was all connected up and the tube "E" was attached to a Chapman air-pump which was kept going until the entire apparatus was free from carbon dioxide. A measured amount of standard barium hydrate was then placed into flasks "a" and "b," and a measured amount of $\frac{N}{10}$ sulphuric acid was placed in "C." The distilling flask "D" was made ready with about 150 cubic centimeters of boiling-hot distilled water.

As soon as the last of the respired ammonia-air mixture had been measured, the beetles were quickly dropped into flask "D" and the distillation was started; also, the air pump connected with "E" was started at the same time. "D" was kept distilling at a boiling temperature for one hour. In that time, it was found, practically all the

ammonia and carbon dioxide would be driven off from the beetles. (i. e., very little more of either gas could be obtained by further boiling.) The ammonia was caught by the acid in "C." This acid became too warm to retain any of the carbon dioxide which was therefore carried over and caught in "b" and "a." The excess of the $\frac{N}{10}$ sulphuric acid in "C," not neutralized by ammonia driven off from "D" was titrated against $\frac{N}{10}$ ammonia water. Thus, the number of cubic centimeters of $\frac{N}{10}$ ammonia given off from the insects could be found, and that number times the factor 0.0017 gave the number of grams of ammonia, from

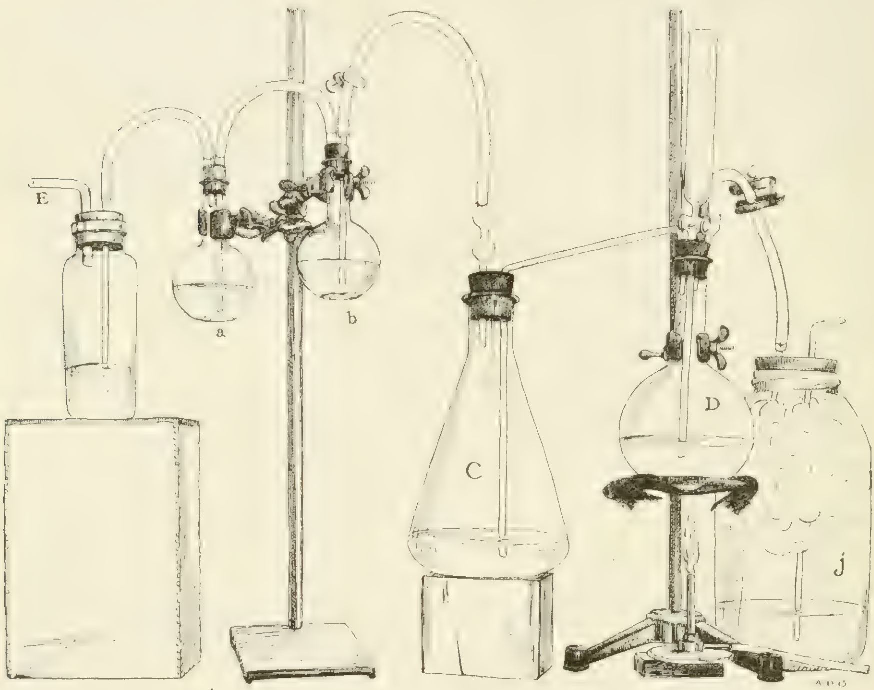

FIG. 6. Form of apparatus used in distilling off NH_3 and CO_2 that had become fixed in insects previously confined in ammonia-air mixture.

which it was easy to determine the volume—one gram of ammonia being equivalent to 1309.7 c. c. of the gas at O° C and 760 m. m. mercury pressure.

The carbon dioxide caught in "a" and "b" was determined in the usual manner.

Now, from several experiments in which untreated insects had been distilled in "D" it was found that a very close average of 0.6 c. c. of carbon dioxide per gram of the beetles was driven off in one hour—after one hour very little carbon dioxide could be driven off by further boiling—i. e., that much carbon dioxide was normally in the living beetles which had been breathing pure air. When obtaining the respiratory ratio in air, this normal amount of carbon dioxide would be left

in the insects at the end. Therefore, in finding the amount of carbon dioxide produced by the insects under the influence of ammonia, 0.6 c. c. for every gram weight of beetles used was subtracted from the volume of carbon dioxide driven off during the process of distillation. The remainder plus any carbon dioxide found in the respired air was taken as the amount produced by the insects during the experiment. Thus, all the necessary data desired was at hand.

Table VII records some important results given in six experiments carried out by the method just described. The beetles used in Nos. 4, 5 and 6 were taken from the same lot as those used in the first three experiments and no doubt would have given similar respiratory quotients in air. Indeed, one determination of the "quotient" was made in air for the beetles used in No. 6, and it was 0.75.

TABLE VII.

Influence of ammonia gas in air upon $\frac{CO_2}{O_2}$.

Exp. No.	Specimens of Passalus cornutus.	Per cent of NH_3 used.	Free CO_2 at end.	Free NH_3 at end.	$\frac{CO_2}{O_2}$	Time (hours.)
1	2 beetles = 3.5 grms	None.	3.15%	None.	0.70	$12\frac{2}{3}$
	Same	1.57%	0.65 c.c.	Almost none.	$\frac{1.19}{3.3}=0.36$	$8\frac{1}{4}$
2	3 beetles = 5.0 grms	None.	3.66%	None.	0.72	4
	Same	3.43%	3.54%	Seemed to be a *little* present.	$\frac{7.58}{17.63}=0.43$	10
3	3 beetles = 4.9 grms	None.	9.23%	None.	0.70	4
	Same	4.5%	6.48%	None.	$\frac{11.62}{20.12}=0.57$	10
4	3 beetles = 4.4 grms	7.47%	None.	1.53%	$\frac{2.09}{4.02}=0.51$	5
5	3 beetles = 4.7 grms	3.00%	None.	1.09%	$\frac{0.81}{2.11}=0.38$	3
6	3 beetles = 4.8 grms	2.3%	1.57%	None.	$\frac{2.65}{6.46}=0.41$	4

When ammonia was used, the respiratory ratio as well as the quotient is given in the table. The denominator of the ratio in each case is the number of cubic centimeters of oxygen used by the insects during the experiment; the numerator, it is believed, equals the number of cubic centimeters of carbon dioxide produced by the insects, under the influence of ammonia, during the experiment. The method of obtaining the values of both numerator and denominator has already been described.

As may be seen, when carbon dioxide appeared in the respired air, all or practically all free ammonia had disappeared from that air—in Nos. 1 and 2 a slight amount of ammonia appeared to be still present.

In case practically no ammonia gas was present at the end of the

experiment, then the amounts of carbon dioxide and ammonia driven off by distillation were very nearly equal—the average difference being only 0.38 c. c.

Experiments No. 4 and 5 show that where ammonia but no carbon dioxide was present in the air at the end of the experiment, considerably more ammonia than carbon dioxide was driven off in the process of distilling the beetles.

No. 4 was the only trial out of the six recorded here where the ammonia was used strong enough to render the beetles apparently dead at the end. In the other trials the beetles became more or less helpless within ten to fifteen minutes after the ammonia gas was applied (sometimes the only signs of life would be a slight twitching of the antennae) but in every case, except Nos. 4 and 5 where ammonia was still present, recovery was quite noticeable before the experiment was ended.

The presence of ammonia in sufficient amounts to kill the insects—enough remaining over uncombined to render the water in which they were distilled decidedly alkaline—did not cause the insect-tissue itself to yield ammonia. That is, no more ammonia was driven off than had been used in the process of treating the insects. Three experiments, not recorded in the table, were especially directed to determine this last point. The three special trials were carried out because one other experiment indicated that such might be the case, but its result seems undoubtedly due to some mistake—most likely to a mistake in the amount of $\frac{N}{10}$ sulphuric acid used in "C."

The various results in this connection, therefore, point strongly to the following conclusion: Part of the ammonia gas in air confined with specimens of *P. cornutus* is rapidly absorbed by them. Some of this absorbed gas appears to unite with carbon dioxide in their bodies at once. If the amount of ammonia is not high enough to kill, carbon dioxide continues to be formed slowly and to unite with the ammonia in the tissues. As this process goes on, more ammonia is slowly absorbed from the air by the tissues until finally almost none remains. Carbon dioxide, produced by the insects after that, begins to be given off in the respired air. Unlike the other insecticide vapors already discussed, it will be seen, the influence of ammonia is to *reduce* the value of the respiratory ratio. Enough ammonia gas to render insects helpless reduces both their intake of oxygen and their production of carbon dioxide, but the reduced respiratory quotient shows that the carbon dioxide production is reduced most.

Since from specimens which were treated long enough for all the ammonia to be used out of the air, ammonia and carbon dioxide were distilled off (at about 212° F.) in *equal volumes* it would appear that they had been united in the tissues in the form of bicarbonate of ammonia.

Vernon[1] in 1906, using ammonia in Ringer's solution with mammalian kidneys found that the respiratory quotient was depressed—the more concentrated the ammonia the more rapid the diminution in the quotient.

He tried hydrocyanic acid also, among other poisons, and found that it caused a slight rise in the respiratory quotient of perfused kidneys.

[1] Vernon, H. M. Journal of Phys. Vol. 35, page 53.

EFFECT OF SERIOUS MECHANICAL INJURY UPON $\frac{CO_2}{O_2}$ OF P. CORNUTUS.

Four experiments were run to determine how the respiratory ratio would behave in case of beetles mechanically injured and dying in pure air from the effects of the injury—i. e., "mechanical injury" was substituted for the insecticide.

In the first case, the head of the beetle was crushed; in the next two experiments, the heads and prothoraxes were crushed; and in the fourth experiment the head was pithed in every direction with a hot steel needle. Death was brought about in periods ranging from 10 to 24 hours. The effect upon the respiratory quotient was comparatively uniform. The average quotient in air before injury was 0.72, after injury it was 0.53 and after death when decay had begun the average had risen to 0.87.

These results are added evidence that the rise in the respiratory quotient during the time beetles are deeply under the influence of gasoline, etc., must be due to some peculiar effect of such insecticides on the respiration of living tissues.

EFFECT OF STARVATION UPON $\frac{CO_2}{O_2}$ OF P. CORNUTUS.

In making all these respiration studies, it was necessary to exclude any food from the respiration chamber. Now since it was important to first obtain the respiratory quotient for the beetles in air, and afterward to make two or three determinations under the influence of the insecticide, they had to be without food, often for 24 to 48 hours or longer—sometimes, even as long as four days. However, the experiments were always carried on in a moist atmosphere, and whenever possible, the beetles were placed with food (partly decayed wood) between experiments for a short time. But the question might naturally arise as to the possible effect of this enforced fast, itself, upon the respiratory quotient. A few "starvation experiments" were therefore carried out in order to know whether this question might have any bearing upon the results obtained in connection with the influence of insecticide vapors on the respiratory quotient.

For each experiment, a strong healthy specimen was taken from food and the $\frac{CO_2}{O_2}$ in air determined. The specimen was then confined in a moist place without food for a time, when the quotient was again determined; and so on at intervals until after death. Results were comparatively uniform. The respiratory quotient remained almost constant for six to seven days, and then began to decline in value. Within about two weeks (a little more or less) it had fallen from 0.71 or 0.74 to 0.54 or 0.50 and remained about that low until death, which did not occur in one case until the end of the twenty-fourth day—when the heart had entirely ceased beating. Very soon after that, as soon as decay had begun, the quotient rose to 0.85 to 0.89. Sometimes the quotient for a decaying insect ran a little higher.

It will thus be seen that all the respiration work with insecticides was well within the period when the respiratory quotients of the beetles (without food) in air remain constant.

CONSTANCY OF THE NITROGEN-AMOUNT IN AIR CONFINED WITH LIVING INSECTS.

Earlier in this paper, proof was promised for the statement that the amount of free nitrogen is not appreciably diminished or increased by insects during respiration. Much care was necessary in deciding the question certainly, because of its importance in the method used for estimating the percentage of oxygen (or other component gas) absorbed from air confined with insects. Besides, Treviranus, 1831, was of the opinion that insects excrete nitrogen in small amounts, very much as they excrete carbon dioxide. The work of Sorg has already been mentioned. Liebe,[1] 1872, and Pott,[2] 1875, carried on experiments with certain insects to determine the amount of carbon dioxide given off per unit of time and body-weight, but they did not determine the oxygen used. Treviranus[3] is the only worker known to me who attempted to estimate both the oxygen absorbed and the carbon dioxide given off by insects in air. He published a table of his estimations, and explained that oxygen was used in amounts greater than the carbon dioxide excreted. Also, he says that in every case the volume of the air became changed at first; but this, he though was only through the animal swallowing a certain quantity of gas. He had observed gas taken into the digestive canal of the leech and some other animals with suctorial organs and seems to have concluded that it was the same with insects. In four or five cases, he obtained a continued decrease in volume which he thought really too great to be accounted for in that way. Still, he drew his conclusions, from his other investigations, that the volume of air with insects remained practically unchanged in respiration. To make up the difference caused by the unequal exchange of oxygen and carbon dioxide, he decided that nitrogen was excreted to the amount of that difference.

Other workers at that early time, using larger animals than insects, fell into the same error, as later workers upon the respiration of mammals have shown.

It was only after a series of experiments that satisfactory proof was finally obtained that the volume of nitrogen in air confined with insects remains practically unchanged.

First, specimens of *Passalus cornutus* were confined in measured amounts of pure hydrogen or of pure nitrogen (i. e., free from oxygen) for several hours at a time. In the case of both gases, after the carbon dioxide excreted by the insects during the interval had been absorbed the volume of the gas remaining was the same as at the beginning, showing that no nitrogen had been added or taken away. Pure hydrogen was obtained by means of a Hempel hydrogen pipette and stored in a gas container over potassium pyrogallate. The apparatus set up for this purpose is shown in Fig. 5, (p. 30). Bulb "Z," of the pipette, contained in its lower part lumps of pure zinc supported by the end of a glass rod. Bulb "S" contained weak sulphuric acid. The container "C" held potassium pyrogallate, which was displaced into the aspirating bottle

1. Liebe, Otto; Inaugural Address, Jena, 1872.
2. Pott; Die Landwirthschaftlichen-Vesuchs-Stationen, etc.—Band XVIII, 1875, p. 81.
3. Treviranus, G. R.; Erscheinungen und Gesetze des Organischen Lebens, 1831, Vol. 1, pp. 358-361—see also table at end of Vol. 1.

as the hydrogen filled "C." "A" was connected with a heavy rubber displacement-bag which served to protect the pyrogallate from the air. As soon as "C" was sufficiently filled with gas and the two-way cock was closed, gas pressure forced the sulphuric acid down to the position shown and the gas-generation ceased. The two glass bulbs forming the left hand portion of the pipette contained mercury.

Nitrogen could be obtained with this apparatus by simply drawing air into "C" and then waiting a few minutes until the alkaline pyrogallate had absorbed all oxygen and carbon dioxide from the confined air.

Experiments were carried out in so nearly the same way with the two gases and the results were so comparatively uniform that the record of a single experiment with nitrogen will be sufficient.

The following experiment was carried out at a temperature of 21° to 22° C. Enough air was drawn into container "C" (Fig. 5) to leave about 200 c. c. of nitrogen. Two specimens of *P. cornutus* (3.46 grams.) were placed in a respiration container and the mercury raised to near the top of this container. It was then at once connected through a capillary tube with the thimble "th" of "C." Nearly all the nitrogen was drawn into the respiration container with the small amount of air that had been left with the beetles. A moment was allowed for this air and nitrogen to mix, after which almost all the mixture was transferred to "C." Transfers were made back and forth, in this way, during a period of 45 minutes so that all the oxygen was taken up by the pyrogallate—the tracheae of the insect had time to become filled with nitrogen. At the end of that time the gas with the insects was tested and found free from oxygen and carbon dioxide. A mark had been made on the respiration container so that between 80 and 85 cubic centimeters of nitrogen could be retained in it. This container was quickly moved to the measuring burette (Fig. 4), in which nitrogen had just been measured during the test mentioned above. The mercury was raised until it poured from the transfer connection-tube of the burette into the thimble of the respiration container, and thus connection was made under mercury seal. All the nitrogen with the beetles was transferred at once to the burette and measured—found 82.85 c. c. of nitrogen. The gas was all immediately transferred back with the beetles and connections left standing until the experiment was ended—time 10¾ hours.

Gas measured at end, 83.30 c. c.
83.28 c. c. after phosphorus pipette.
82.85 c. c. after KOH pipette. (Nitrogen).

0.45 c. c. of CO_2

The hearts were beating within one-half hour after these beetles were removed to fresh air and both beetles recovered.

It will thus be seen that the amount of nitrogen at the end was the same as at the beginning of the 10¾ hour period. The volume of the gas with the beetles had increased 0.45 c. c. during the confinement—the increase being due to carbon dioxide which the beetles were able to excrete even in the absence of any free oxygen. There were no white fumes in the phosphorus pipette at all, showing that no oxygen was

present; the slight decrease in volume upon transferring to this pipette was no doubt due to the water taking up a little carbon dioxide.

The experiment given is an average one as carried out by this method with hydrogen and nitrogen gases.

A word of explanation is due as to the means of forcing all the gas out of the respiration container from around the beetles.

When mercury had been brought up to the top—i. e., to the two-way cock of the container—the cock was closed, and the aspirating-mug of mercury connected with the respiration container was then lowered six inches. Bubbles clinging around the wing covers would at once rise. The mercury-mug was raised again, the cock was opened and these last bubbles of gas could be forced over. By using care to bring the mercury-mug down the same distance each time when causing the last bubbles to rise, three successive measurements of a quantity of gas might be made with a variation less than 0.1 c. c. It was surprising to find how little the beetles were injured, under proper precautions, during the operation. Even in the case of active beetles from air, mercury was seldom forced into the tracheal system or into the digestive tract and when the beetles had first been rendered quiet with nitrogen (or other gas) such an accident scarcely ever occurred.

When it had thus been found perfectly possible to measure all the air used with the beetles at the beginning and at the end of an experiment, the question was tested out with the beetles in pure air.

(Exp.) Used one beetle, wt. 1.89 grms.

Air at beginning 81.7 c. c. measured by the burette (Fig. 4.)

81.1. c. c. after $5\frac{1}{2}$ hours with insect. 0.6 c. c.. loss.
79.17 c. c. after absorption of CO_2 with KOH.
1.93 c. c. — = 2.37% CO_2
64.73 c. c. after Phosphorus-pipette = nitrogen at end, 79.81% N.
14.44 c. c. oxygen remaining = 17.8% O_2

The nitrogen percentage of the air used at the beginning was 79.2.

81.7 c. c. $\times$ 79.2 = 64.70 c. c. nitrogen at beginning; an amount which corresponds almost exactly with that found at the end—i. e., 64.73 c. c. (Also, experiments of this kind afford opportunity to compare the respiratory quotient, given by the percentage method already described, to the quotient given when the actual number of cubic centimeters of carbon dioxide given off is divided by the actual number of cubic centimeters of oxygen absorbed. The quotients given by the two methods agree within two hundredths.)

Now, since the volume of nitrogen at the end was the same as at the beginning, the 0.6 c. c. loss in air-volume, found by actual measurements, must have been due, alone, to the fact that a volume of oxygen was absorbed by them greater than the volume of carbon dioxide excreted.

By the same method the question was tested out with specimens of *Melanoplus femoratus*—a species which was used in some of the respiration work—and within the limits of the possibility of error of the method the amount of nitrogen remained the same in every case. When the carbon dioxide in 76.9 c. c. of air confined with six of the grass-

hoppers had risen to 8.3% even, the nitrogen-volume was only 0.05 c. c. less at the end than the estimated amount for the sample.

PROOF BY ACTUAL VOLUME MEASUREMENT THAT GASES AND VAPORS MAY BE ABSORBED INTO THE BODY-TISSUES OF INSECTS.

In the first part of the paper evidence was given that the tissues of insects may absorb gases and vapors confined with them. Proof by actual volume measurement may most conveniently be given here. Briefly, the general method used was as follows: An accurately measured amount of the air-vapor mixture (or of the pure gas, in some instances) was transferred from the burette (Fig. 4.) to insects in a container from which pure air had just been expelled by mercury. Then after an interval of time, the whole amount was returned to the burette and again accurately measured. The difference in volume between the readings showed whether gas had been given off, or taken up, by the insects. By transferring back and forth at intervals and measuring in this manner, something could be learned of the rate of absorption. In order to determine whether an absorbed gas may be given off or exhaled again, the manipulation just described was reversed. That is, insects were placed in a respiration container with the gas (vapor) or air-gas mixture for about thirty to sixty minutes. This gas was then all pushed out of the container and a measured amount of pure air introduced from the measuring burette. After various intervals of time the gas was again measured. Table VIII, (p. 50) records the result of some of these absorption and exhalation experiments. Besides the gases given in the table, formaldehyde gas,* ammonia, hydrogen and the vapor of ether were tried with similar results.

As may be seen from the table, when a measured amount of one of these gases or air-gas mixtures was transferred to insects that had been in air, the volume of the transferred gas quickly decreased. The greatest decrease came in the first three to five minutes. After ten minutes any decrease could be accounted for by respiration—except in case ammonia, sulphur dioxide or hydrocyanic acid gas had been used. These three gases continued to be absorbed while the insects remained alive.

The exhalation which was given off to pure air from insects saturated with some gas-mixture was slower than the absorption. With gasoline, carbon disulphide, nitrogen, hydrogen, carbon dioxide and formaldehyde, however, all (or all but a trace) of the measured amount of vapor absorbed could be finally recovered. When ammonia, sulphur dioxide, or hydrocyanic acid gas was used, very little could be recovered by exhalation; and if it were transferred once more to the insects, it would be slowly taken up again. Oxygen, once taken up by the tissues, could not be recovered as such—at least, not in appreciably measurable amounts. It seemed to reappear only in combination, as carbon dioxide and moisture. The fate of the greater part, at least, of the ammonia absorbed has already been explained in this paper. Sulphur dioxide and hydrocyanic acid gas seemed to become fixed in some non-volatile combination within the insect tissues.

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*Beetles confined in formaldehyde-gas-air-mixture which was obtained by allowing 100 c.c. of air to become saturated above 10 to 15 c.c. of a 40 per cent solution of formaldehyde at 23° C. were scarcely able to move after two hours. The largest, strongest specimens became quiet only after about 3½ hours. When removed to fresh air after being so deeply affected, the heart-beats might improve for a time but the insects did not recover fully and died after 6 to 8 hours. Formaldehyde gas had to be present in high percentages to kill and even then its action was slow.

TABLE VIII.

Measurements of Absorptions and exhalations.

Exp. No.	Specimens.	Insects saturated with—	Gas transferred to insect.	Volume of gas used at beginning.	Interval (time.)	Volume of gas after interval.	Loss in volume.	Gain in volume.
1	3 Melanoplus femoratus	Air	Air with 7 to 8% of gasoline vapor	71.3 c.c.	10 min.	70.65 c.c.	0.65 c.c.	
					15 min.	70.6 c.c.	0.05 c.c.	
2	8 Same species	Air	Air with 5.2% of gasoline vapor	78.55 c.c.	6 min.	77.45 c.c.	1.10 c.c.	
3	4 Same species	Air with about 7% gasoline vapor	Air	73.55 c.c.	10 min.	74.1 c.c.	....	0.55 c.c.
4	5 Same species	Air	CS_2—air	76.45 c.c.	5 min.	76.0 c.c.	0.45 c.c.	
					15 min.	76.0 c.c.	Practically none.	
5	6 Same species	CS_2—air	Air	75.55 c.c.	10 min.	76.1 c.c.	....	0.55 c.c.
6	4 Same species	Nitrogen	Air	77.35 c.c.	10 min.	77.45 c.c.	....	0.10 c.c.
7	4 Same species	Air	Nitrogen	62.10 c.c.	10 min.	62.15 c.c.	....	.05 c.c.
8	7 M. femur-rubrum	Air	Air with 27.5% SO_2	79.05 c.c.	3 min.	74.45 c.c.	3.6 c.c.	
9	9 M. femur-rubrum	Air	Air with 27% SO_2	83.25 c.c.	3 min.	79.3 c.c.	3.95 c.c.	
					6 min.	76.7 c.c.	2.6 c.c.	
					10 min.	75.0 c.c.	1.7 c.c.	
					15 min.	73.6 c.c.	1.4 c.c.	
					20 min.	72.5 c.c.	1.1 c.c.	
10	3 Passalus cornutus	Air	Air with vapor from To-bak-ine	79.23 c.c.	10 min.	79.08 c.c.	0.15 c.c.	
11	2 Passalus cornutus	Air	Air with 2.97 % of HCN	82.05 c.c.	8 min.	80.25 c.c.	1.80 c.c.	
12	Same as No. 11	Air with 2.97% HCN	Air	77.7 c.c.	8 min.	78.25 c.c.	....	0.55 c.c.
					15 min.	78.25 c.c.	....	No more.
13	6 Melanophlus femoratus	Oxygen	Pure CO_2	73.65 c.c.	5 min.	70.85 c.c.	2.8 c.c.	
					40 min.	70.1 c.c.	3.55 c.c. in all.	
14	6 Melanoplus femoratus	CO_2	Oxygen	72.35 c.c.	10 min.	73.85 c.c.	....	1.5 c.c.

In discussing the influence of gasoline and kerosene vapors on the respiratory quotient of insects (see Table V.) it was shown by estimations that the percentage of vapor of these insecticides was lowered during the time they were left with the insects. By the same method of estimation described there ($H_2S\,O_4$ pipette, etc.) it was proven in this connection that the gain in volume of "air transferred" to insects that were saturated with air-gasoline vapor was due to gasoline vapor given off—i. e., the gain in volume and the amount of gasoline vapor found in the "transferred air" afterward were equal. When carbon dioxide was used, its amount in the "transferred air" afterward could be found by estimation also. The odor of carbon disulphide, or of nicotine could be easily detected in "transferred air" when the vapor of either had been previously placed with insects.

Dry, clean insect chitin of *Passalus cornutus* was tried. It would take up these gases and give them off again in pure air, but the amount that it could take up per unit weight was only about one-third that taken up by living insects.

The proof would seem to be complete, therefore, that living insect tissues may take up the gases or vapors named very rapidly and give them off again to pure air or to other gases; except as was specified for oxygen, ammonia, sulphur dioxide and hydrocyanic acid gas. In general, the greater the difference between the tension of any gas in the air above its tension in the insect tissues, the larger was the amount of the gas that became absorbed and vise versa. For example, if a group of insects were kept in pure carbon dioxide for about two hours (until no nitrogen was left in the tissues) and then suddenly pure nitrogen was transferred to them, the amount of nitrogen absorbed was greater than if it were transferred to insects that had been kept in air.

But not all gases were equally soluble—if that expression may be used—in the insect tissues. Nitrogen was taken up in the least amounts of any of the gases tried. Experiment No. 7 of table VIII shows a slight *increase* in the volume when nitrogen was transferred to insects that had been kept in air. Seemingly, a *decrease* was to be expected, if nitrogen were absorbed; but an actual increase was brought about because the carbon dioxide given out of the bodies of these insects, in the ten minute interval, was greater than the nitrogen taken up. In this particular experiment (No. 7) 0.2 c. c. of carbon dioxide had been given off and 0.15 c. c. of nitrogen had actually been taken up by the insects. (These insects had been respiring normally in air just previous to the nitrogen transfer.)

Experiments were made at transferring pure oxygen to insects after they had been in pure carbon dioxide, and vise versa. Also, respiration experiments with insects in air and in pure oxygen were compared. Note that in experiment No. 14 there was a gain of 1.5 c. c. in a measured amount of oxygen transferred to insects which had been in pure carbon dioxide, showing that the carbon dioxide given off was greater than the volume of oxygen taken up. Estimation showed that 1.2 c. c. of oxygen had been taken up while 2.7 c. c. of carbon dioxide had been given off. Thus all the experiments in this connection went to show that, for a quick interval, carbon dioxide was more soluble in the insect tissues than oxygen. However, oxygen would continue to be taken up when present in the least amount at all and, as has already been stated,

no appreciably measurable amount would be given off again when once it had passed into the insect.

Continued respiration in oxygen was no more rapid than in air.

The oxygen used for these experiments was obtained either from electrolysis of water or by the use of "Oxone" (i. e., fused sodium peroxide) and water.

Now, when air or oxygen was transferred to insects previously confined for several hours in carbon dioxide, nitrogen or hydrogen, it should be noted that the first rapid exchange of gases took place while the insects were lying entirely helpless without any noticeable respiratory movements. Visable proof of the passage of oxygen (without the aid of respiratory movements) into insects was obtained in the following manner: The wing covers of specimens of *P. cornutus* were removed and nearly one-half cubic centimeter of a saturated solution of Indigo Carmine was injected through a fine hypodermic needle, into the body cavity of each. The insects were then put into glass containers in pure carbon dioxide, so as to exclude all oxygen. At that time the abdomens, as seen from above, were intensely dark blue. After twelve to fourteen hours without air, however, the tissues had reduced all the Indigo Carmine to its leuco compound and the internal organs of the beetles could be seen again (through the dorsal surface) entirely white to yellowish white. When the beetles were then removed to air, the abdomens began coloring almost at once. Within five minutes the blue color had extended and deepened so that the abdomen was as blue as when first placed in the carbon dioxide. The coloration began most noticeably at the sides near the spiracles. As is well known, Indigo White becomes blue Indigo Carmine as soon as oxygen reaches it. The experiment therefore, afforded visible proof that oxygen passed to all internal parts of the abdomen without the aid of respiratory movements—the heart was not beating even, when the blue color was reappearing.

Methylene Blue could be used in the same way, but the reduced, white compound of this dye does not reoxidize so rapidly as the reduced Indigo Carmine.

INFLUENCE OF CARBON DISULPHIDE UPON THE LUMINOSITY OF THE PHOTOGENIC ORGANS OF PHOTURUS PENNSYLVANICA LARVAE.*

The larva of *P. pennsylvanica* has a pair of Photogenic organs on the ventral outer portions of the eighth abdominal segment. When pure carbon dioxide was rapidly admitted to living specimens of the larvae in a respiration container above mercury, the phosphorescent light—even when in full glow—would quickly die out. When air or oxygen was admitted again, the glow would reappear. Also, if the organs were cut out separately when the insect was causing them to glow brightly, the light would continue for some time.

Organs cut out in this way and placed at once on wet blotting paper would give off light in a dark room for thirty minutes or more. When these organs on wet paper were placed in a respiration container above mercury, the light would cease in pure carbon dioxide just as in case of the living insects. Upon admitting air the glow reappeared again

*Specimens were obtained from Mr. C. S. Brimley, Raleigh, N. C.

at once, in the dark. The glow then, when once started, seemed to depend upon some oxidition process.

Now, in the dark room, if a wet paper supporting one of the glowing photogenic organs was introduced into a test tube containing vapor of carbon disulphide, the light would rapidly dim and the organ become invisible. If removed at once to pure air, the glow would reappear gradually, but it never became quite as bright as before.

Carbon disulphide therefore, in the presence of air, could produce the same result as pure carbon dioxide—i. e., as the absence of oxygen.

This effect of carbon disulphide upon the luminous organs of *P. pennsylvanica*, taken in connection with its effect upon the respiratory quotient of insects furnishes additional evidence that this insecticide (as also the others which produce similar effects upon the $\frac{CO_2}{O_2}$) is able to interfere directly with the taking up of oxygen by the insect-tissues.

The question naturally arises—can it be that the mere presence, alone, of the vapors of carbon disulphide, kerosene, gasoline, turpentine, and similar volatile oils tend to prevent something, in the tissues from uniting with oxygen to start the oxidition process. Such a thing seems not impossible, when it is remembered how a very slight per cent of many of those same vapors will check or prevent moist phosphorus from taking up oxygen.

II. SOME PROPERTIES OF LIME-SULPHUR WASH THAT MAKE IT EFFECTIVE IN KILLING SCALE INSECTS—ESPECIALLY SAN JOSE SCALE.

Lime-sulphur is discussed, here, somewhat apart from the other insecticides. The reason for this will be apparent in the following pages.

When this insecticide was tried upon large insects, having rather heavy chitinous walls, it seemed to have very little effect. Specimens of *Passalus cornutus* and large tomato-worms were not killed even after being submerged for two minutes in lime-sulphur solution of the strength recommended as a winter spray. They showed some irritation for a time but this wore off in most cases with no apparent permanent injury. Upon more delicate insects with thin chitin, the irritation was greater, apparently, and if the wash were applied to a small portion of a very delicate body-wall (like the body of a covered scale insect) that part might be killed before the rest of the body. But no means could be found to prove, satisfactorily, that the lime sulphur wash had penetrated into the body.

Now lime-sulphur is recognized as a special rather than as a general contact insecticide. It has been recommended by entomologists as an effective agent against scale insects (particularly San Jose scale) more, perhaps, than against any other form of insect life. San Jose scale is found living in a partially grown condition under its small scale-covering at a time of year (Fall, Winter, Spring) when the wash can be applied strongest without injury to the tree.

In the Insectary, an orange tree which was covered with *Aspidiotus (Chrysomphalus) ficus* afforded excellent opportunity for studying the action of the wash on scale insects. First, it was found that when home-made wash (Lime 20 lbs., sulphur 15 lbs. and water 50 gals.) was applied to these scales it rendered many of them partly dormant after a few hours. That is, when the scale coverings were lifted up from insects, a few hours after they had been treated, many of the little insects were unable to move until after three or four minutes exposure to the air. When untreated scale-coverings were lifted, the muscles of the delicate walled insects contracted, usually, so as to telescope the abdomen and pucker the body up into a shapeless little lump. If the contraction had not occurred upon lifting the scale, a touch with a needle point would cause the body to contract as described. But many of the insects beneath treated scales would not respond, even to the needle prick, until after they had been exposed to the fresh air (i. e., after the scale-covering had been lifted) for a few minutes; and then the response, when it came, was sluggish or slow.

Similar results were observed when home-made concentrate diluted to the strength of a winter wash was used.

It had been suggested by some that the odor often noted on sunny days in orchards freshly sprayed with lime-sulphur was similar to that of sulphur dioxide. Knowing that small amounts of that gas can readily bring about torpor and death in insects, tests were arranged to determine whether the gas is actually given off from a surface sprayed with the wash. Lime-sulphur on paper and on twigs (both moist and dry) was placed above mercury in the respiration chambers already described, and allowed to stand confined with the air for various periods of time up to ten days. For about five hours each day the containers were exposed to strong sunlight. The air thus confined was tested for sulphur dioxide by passing it into a solution of iodic acid with starch paste. No trace of sulphur dioxide was found in any case. Other experiments went to show that sulphur dioxide would not be formed in appreciable amounts from the sulphur deposited by lime-sulphur except at temperatures much above those found under spraying conditions in the orchard.

It was noticed, however, in these experiments in which lime-sulphur was confined with air, that the volume of the air was decreased. The decreased volume was found to be due to a loss of oxygen. This was not strange, since Haywood* ('07) and others have shown that lime-sulphur wash is composed largely of polysulphids of calcium which oxidize on exposure to the air, forming calcium thiosulphate and free sulphur—the thiosulphate oxidizing further to the sulphite and this, perhaps, finally to the sulphate. The surprising thing was this—the loss in volume, as noticed, indicated that very considerable quantities of oxygen had been used. When a scale was covered with the wash, could it be possible that oxygen was used in such amounts as to partially or wholly deprive the insect beneath the scale-covering of that gas?

A study was next made to discover whether the bodies of the little insects rendered comatose beneath scales treated with lime-sulphur had really all been wet with the spray. From observations already made it had seemed that some of them at least had not been wet at all. It was

*J. K. Haywood, Feb. 1907, Bulletin 101, Bureau of Chemistry.

found that the insecticide was apt to stick especially well around the circle where the margin of the scale was in contact with the plant surface. Even under favorable drying conditions, a wet circle of the lime-sulphur solution was likely to be found for two or three hours around the scale-margin—sometimes for a longer period. In many cases the solution had passed under the margin of the scale after an hour or two and had wet the pygidium of the insect as, sometimes, also the sides of the abdomen. None of the insects were found with the dorsal surface of the body wet—i. e., the solution was not able to penetrate the older portion of the scale. After eight to ten hours or longer, some of the insects would be found with the pygidium stuck fast in the dry wax at the margin of the scale. Also, before the margins of treated scales had become entirely dry, it was found that in some cases soft wax was sticking to the pygidium and as the scale was pulled slowly away from the insect a comparatively broad thread of wax would draw out between them (see plate II, Fig. 4.) This showed that after some time in contact with the scale, the yellow solution was able to soften the more recently secreted wax. Not a single instance was found with this species, where the wax could be drawn out into a thread from the edge of untreated scales.

After scale-insects whose bodies had been wet with the lime-sulphur had died, the portion of the body that had been wet always darkened with decay first (provided the body was kept where it did not dry up) indicating the tissues in that portion had died first. The irregular dark area along the pygidium and abdominal margins of the scale-insect photographed in Plate II, Fig. 3, is a true representation of that condition.

But the comatose insects under many of the treated scales (as in former observations) did not seem to have been wet at all. The insects were so small, however, it was very hard to tell certainly whether some portion of the body might not have been wet slightly by the insecticide. Finally, a means was found to aid in detecting any portion of the body that was wet with lime-sulphur solution. A saturated solution of alcoholic corrosive sublimate was used to give a black precipitate in the presence of any yellow lime-sulphur. If just a little lime-sulphur was placed on the dorsal surface of a white-bodied scale insect, and this was then touched with the corrosive sublimate solution a black spot resulted.

In contact with a thin walled insect, however, the lime-sulphur seemed to oxidize to the colorless thiosulphate more rapidly than on white paper, and thiosulphate of calcium would not give the precipitate with corrosive sublimate. A fresh saturated solution of silver nitrate could then be used; it would give a black precipitate with calcium thiosulphate at once. Of course, silver nitrate exposed with organic matter will blacken after a while, but not at once as described with the thiosulphate. Even with the aid of these two test solutions there were a good many cases of comatose insects (whose scale-coverings had been treated with lime-sulphur) in which no indication of their bodies having been wet with the insecticide could be found.

This fact added weight to the suspicion that some of the treated insects might be comatose from the lack of oxygen.

Further experiments were started to learn something of the amount

of oxygen that may be used by lime-sulphur on a sprayed surface; also the rapidity with which the gas might be absorbed. The lime-sulphur solution was confined on either filter paper or glass wool above mercury in respiration containers—using measured amounts of air for various intervals of time. By this method it was soon determined definitely that large amounts of oxygen were absorbed. Results of some of these experiments are given in table IX.

'ABLE IX.

Absorption of oxygen by lime-sulphur. (Beaume 20.1°.)

Ex. No.	Size of paper.	Weight of lime-sulphur.	Condition.	Hours.	Oxygen used.
1	1200 sq. cm	4.1 grms., when dry	Moistened for use in the experiment.	6½	32.7 c.c.
2	Same		Same	next 1½	1.89 c.c.
3	1200 sq. cm	5.2 grms., when dry	Moistened for use in the experiment.	16½	*87.5 c.c.
4	900 sq. cm		Dry when used	3½ days.	1.8 c.c.
5	Same paper		Moistened	5½ hrs.	11.0c.c

* This was all the oxygen in 422.6 c.c. of air.

In these experiments a piece of filter paper with a measured surface (both sides) was weighed dry. It was then wet with all the lime-sulphur (Beaume′ 20.1°) that it would hold, after which, it became quickly dried as thoroughly as possible out of doors by hot sunlight, and weighed again. The difference between the latter weight and the weight of the paper is recorded in the table as the amount of dry-lime sulphur exposed. When this lime-sulphur paper had been moistened it used oxygen more rapidly than when dry (compare experiments No. 4 and 5, Table IX). Besides, considerable oxygen was used during the process of drying, before the lime-sulphur was weighed. At the end of experiment No. 1, nearly all the yellow polysulphide color had disappeared from the paper. After that, as indicated in experiment No. 2, oxygen was used more slowly. It appeared from such experiments that the polysulphides must use oxygen much more rapidly (or in greater amounts) than the thiosulphate. Calcium thiosulphate was obtained from Eimer and Amend and from Merck. Experiments with this compound carried out in the manner already described for lime-sulphur showed that oxygen was used slowly. For example, 1200 sq. cm. of paper surface wet with a white wash of calcium thiosulphate (and used wet) took up only 1.6 c. c. of oxygen in sixteen hours. The orange colored lime-sulphur solution, then, is the stronger reducing agent. Used in excess, it will render deep blue solutions of Indigo Carmine colorless at once; and the so-called caustic action of the wash on the hands seems rather due to this strong reducing power than to the alkalinty of the solution.

Experience with *P. cornutus* and certain grasshoppers showed that these insects could get along with very little oxygen; plant lice, it had been found, used relatively much more oxygen than the larger insects. It seemed worth while therefore, in this connection, to determine how long San Jose scale insects could live without oxygen and still recover. The question was tried out in the following manner:

Apples (fruit) that were infested with San Jose scale, were obtained. Tiny blocks of apple were cut out so that each scale would be supplied with enough sap to keep her from drying up for a time. After many specimens had been prepared in this way, they were divided so that part of them could be kept in the air as a check and the rest could be placed in containers of pure nitrogen above mercury for different periods of time.

At the beginning, three or four changes of nitrogen were used with the specimens until all air had passed by diffusion from the pieces of apple in the containers. (A specimen of *P. cornutus,* placed in one of the containers of nitrogen with the pieces of apple, bearing scales, became motionless within ten minutes. The beetle recovered entirely at the end of the experiment.) Results for the check specimens that had been kept in air, as well as for specimens confined fifteen hours and eighteen hours, respectively, in pure nitrogen are given in table X.

TABLE X.

San Jose Scale in nitrogen 18 hours.

(Examined 48 hours after being removed to air.)

Dead.	Doubtful.	Alive.
3 males. 73 less than half grown. 6 adults. 6 adults having 25 young under the scales with them.	2 young. 15 less than half grown. 5 adults.	1 half grown.

Check in air 66 hours.

Dead.	Doubtful.	Alive.
7 adults, 13 young } dry	2 young. 4 less than half grown.	65 less than half grown. 19 adults. 8 adults with 38 young under the scales with them.

San Jose Scale in nitrogen 15 hours.

(Examined 48 hours after being removed to air.)

Dead.	Doubtful.	Alive.
21 adults. 81 less than half grown. 6 adults with 21 young with them.	33 young.	6 about half grown specimens.

The specimens that had been kept in nitrogen* were removed and then kept in air alongside of the check specimens for two days in order that they might have time either to show that they were dead by shriveling and turning dark), or to recover from the nitrogen if they were still alive. Then they were examined. The specimens marked "doubtful" in the table had not shriveled or decayed but they would not respond to the touch of a needle point. Those marked alive, showed by movement that they were alive. The checks, kept in air, showed that the little pieces of apple were able to furnish the necessary moisture to keep the scales alive for the time of the experiment. Of those

*It was interesting to note that the pieces of apple kept in nitrogen stayed almost the color of freshly cut apples until they were exposed to the air at the end of the test.

kept in nitrogen for eighteen hours almost all were dead. Several were alive at the end of fourteen or fifteen hour periods.

For a comparative study, *Aspidiotus ficus* on the orange tree was treated as follows: One portion of the tree was treated with lime-sulphur diluted to the strength of a winter spray for San Jose scale. Part of the portion so treated was examined at the end of fourteen hours and the remainder at the end of seven days. Another portion of the tree was treated with white-wash made of slaked lime. A third portion was treated with a wash made of calcium thiosulphate paste. Enough of this paste was used to leave a white coating on the tree.

Table XI gives the results of all these treatments.

TABLE XI.

Aspidiotus (Cyrysomphalus) ficus on orange: 1. *Treated with lime-sulphur, Beaume 21°, diluted with 4½ parts of water.*

(Examined 14 hours after treatment.)

Dead.	Alive but dormant at first.	Active.	
		Wax sticking to pygidium.	
3 young. 2 half grown. 5 adults.	14 adults. 3 less than half grown.	3 adults alone. 3 adults. with { 8 dead young and 6 living young.	1 adult alone. 2 adults with 2 young and 7 eggs under the scales with them.

(Examined 7 days after treatment.)

Dead.	Show life.	Alive, sealed in with young under the scales.
15 adults. 30 less than half grown.	5 adults with no eggs or young. 5 less than half grown.	11 adults found with { 140 dead young. 104 living young. 33 eggs. One specimen had { 9 living young. 22 dead young. 4 eggs.

2. *Treated with whitewash.*

(Examined 10 days after treatment.)

Dead.	Alive.	Alive with young.
4 young. 2 adults scaled off.	8 adults. 15 about half grown.	10 adults with { 52 young alive. 31 eggs. One of the adults had { 8 young alive. 6 eggs.

3. *Treated with calcium thiosulphate.*

(Examined 6 days after treatment.)

8 adults. 31 less than half grown. 4 other adults were doubtful.	7 adults. 18 half grown. 6 less than half grown.	11 adults. with { 33 dead young. 48 living young. 38 eggs.

TABLE XI.—Continued.

4. *No treatment.* (*Check.*)

2 adults. 8 young under different mother-scales.	98 less than half grown. 46 about half grown.	35 adults. with { 121 living young. 8 dead young. 142 eggs. One adult had { 5 young. 6 eggs.

The order of efficiency as shown by this table is lime-sulphur, calcium thiosulphate, whitewash—the last named being a little better than no treatment. In case of the lime-sulphur treatment, a greater proportion of the scale-insects were dead after seven days than after fourteen hours.

Just here, the effect of the lime-sulphur in softening the wax must be noted. After seven days it was found that in several cases the softened wax on the scale margin had dried and in so doing had become stuck to the surface of the plant so closely as to confine the young with the mother. Under untreated scales, five young and six eggs were the largest numbers found; but under some of the scales after seven days treatment as many as four eggs, nine living young and twenty-two dead young were found. This showed clearly that in some cases the young could not escape but were literally *packed* under the scale-covering of the mother—sealed in. Such a condition must of necessity bring about the death of all insects under the scale from over-crowding.

Many of the scales treated with lime-sulphur and left on the tree from three to four weeks showed the condition represented in Plate II, Fig. 1. It appeared that the lime-sulphur had become entirely oxidized and a white crust stooled up from the scale—especially around the margin of the scale—so that the latter was pushed loose from the surface of the plant and could be easily brushed off.

The results, fourteen hours after treatment with lime-sulphur, showed again that many scale insects were more or less comatose at first, but revived somewhat after a few minutes in fresh air. They would contract, after a little while, upon being touched with a needle point. They revived quicker than specimens that had been kept in pure nitrogen for fourteen hours—but they certainly did appear to revive because fresh air was admitted when the scale was lifted.

A series of experiments were carried out with a dormant apple tree, to determine whether the tree was respiring or whether its bark might be able to furnish oxygen through photosynthesis.

A small apple-tree was taken from the nursery just after the leaves had been killed by frost in the Fall, and potted. A glass cylinder was fastened around the body of this tree air-tight and arranged so that air could be drawn into the cylinder or expelled through a two-way cock by means of mercury. The arrangement may be readily understood from Fig. 7. By means of the apparatus described under the respiration work with insects, then, it was comparatively easy to determine how much carbon dioxide was given off and how much oxygen was used from a certain area of the tree in any interval of time.

Results of four experiments carried out with this apparatus are recorded in Table XII.

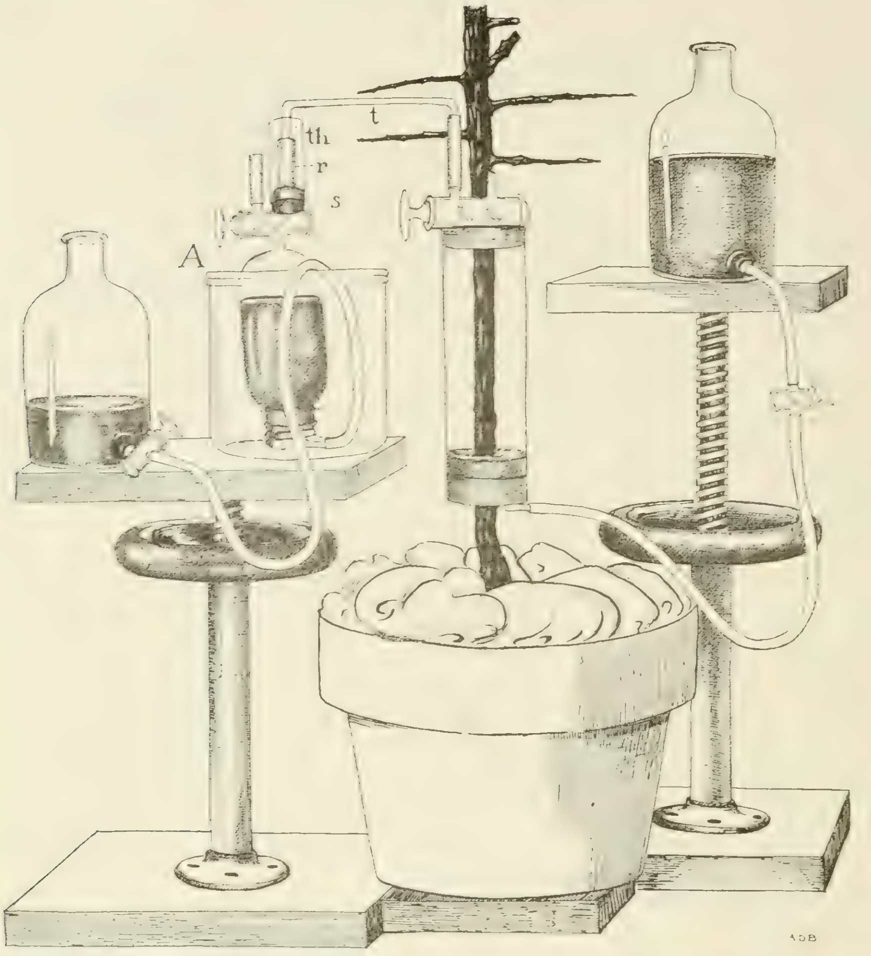


FIG. 7. Dormant Apple-tree confined in a gas-tight glass cylinder containing air. Aspirating bottles contained mercury. "A" = gas. container; form used in respiration work with insects. "th" = the "thimble device."

TABLE XII.

Respiration of a dormant apple tree.

(Bark surface used = 58 sq. cm. Air 240 c.c.)

Exp. No.	Time.	Hours.	CO_2 (total.)	O_2 (total.)	$\frac{CO_2}{O_2}$	Temp.	O_2 used per sq. m.m bark-surface per hour.
1	Night......................	16	1.4 c.c.	1.84 c.c.	0.76	11° —12° C.	0.0197 cu. m.m.
2	Cloudy day.................	8	0.9 c.c.	1.09 c.c.	0.82	22° —19° C.	0.023 cu. m.m.
3	Night......................	16	1.85 c.c.	2.18 c.c.	0.84	19° —22° C.	0.023 cu. m.m.
4	Sun........................	9	0.87	1.14 c.c.	0.76	22° C.	0.021 cu. m.m.

Seven respiration experiments, in all, were carried out with this dormant apple tree. The range of temperature, and of light and dark conditions is represented in the table. In every case oxygen was used by the tree and carbon dioxide given off.

It is certain that the scale insects themselves respire, taking up oxygen and giving off carbon dioxide, but no determinations of the rate of respiration for these delicate bodied insects was obtained. Respiration experiments with plant lice, however, were carried out which showed that (per unit of body weight) their respiratory activity was much greater than for larger insects tried (see No. 5, Table IV, for example). Furthermore, it was found that respiration (per unit of body weight) in young plant lice, was nearly twice as active as in the case of adults of the same species. It seems very probable, therefore, that the comparative respiratory rate for minute scale insects is rather high.

On a dormant apple tree, then, the limited air space about a scale insect (the scale covering of which has been treated with lime-sulphur) must tend to become deficient in oxygen from three causes:—

The tree on one side is using oxygen and giving off carbon dioxide. On all other sides is the waxy scale covering coated with lime-sulphur which uses oxygen more or less rapidly, depending upon moisture conditions, and which tends at first to seal the scale to the tree. Finally, the enclosed insect itself uses oxygen and gives off carbon dioxide.

All this is not absolute proof that the scale insect, which becomes comatose (i. e., unable to move until after being exposed to fresh air) beneath a treated scale-covering, suffers from lack of sufficient oxygen; but it is much good evidence that such may be the case.

One other possibility should be suggested. It is now well known, and may be easily shown, that carbon dioxide in considerable amounts, when confined with lime-sulphur gives rise to hydrogen sulphide. This is a poisonous gas to insects; and with a solution of lime-sulphur present, all the conditions would exist for the formation of a small amount of that gas beneath the scale-covering of a living scale insect. But no means could be found to prove the presence of hydrogen sulphide, satisfactorily, beneath a treated scale-covering.

Two properties—strong reducing power (i e., great affinity to take up large amounts of oxygen) together with the ability to, at first, soften or partially dissolve the newly secreted wax at the margin of the scale —appear to be the most important in making lime-sulphur an efficient scalecide. If this is true, then that chemical combination of lime and sulphur which will make the strongest, most persistent reducing agent, and whose solution will at the same time be able to soften the wax about the margins of the scale-covering best, would seem to be the most desirable combination for a wash against scale insects.

Laboratory tests have shown that anything which tended to increase the alkalinity of the wash, enabled it to more readily attack the wax of the scale. Ammonia, potassium hydrate, and whitewash made from slaked lime were tried. The latter would, of course, be cheapest and it would seem most likely to prove practical.

When a solution of potassium hydrate was added to lime-sulphur the potassium replaced some of the calcium, throwing it down as a precipitate. Ammonia seemed to affect no combination with the sul-

phur, but it did assist in attacking the wax in test tube experiments. From a spray, however, it rapidly evaporated. Experiments were tried out to find what effect whitewash, used to dilute concentrated lime-sulphur, would have on its ability to take up oxygen. Two equal samples from the same stock solution of concentrated lime-sulphur were taken. One sample was diluted with water to the strength recommended for use against San Jose scale by the Geneva, N. Y., station;* the other was diluted with a volume of whitewash equal to the water used with the first sample. Three separate sets of duplicate experiments were run using 2 c.c., at a time, of each diluted spray solution exposed for eighteen hours on filter paper in the gas containers. It was found that after that length of time oxygen was used very slowly, indeed. In fact, the polysulphide color disappeared from both dilutions in the first few hours of the experiments.

One set of results is recorded in Table XIII.

TABLE XIII.

Oxygen used by lime-sulphur.

(Beaumé 23.5°, diluted with 4⅘ parts of water.

Exp. No.	Volume of diluted wash.	Condition.	Hours.	Oxygen used.
1	2 c.c.	Absorbent moist during the experiment	18	10.65 c.c.
2	2 c.c.	Same	18	10.7 c.c
		(Same sample of lime-sulphur, diluted with 4⅘ parts of whitewash.)		
1	2 c.c.	Same	18	15.4 c.c.
2	2 c.c.	Same	18	15.35 c.c.

As may be seen at a glance, the sample diluted with whitewash used considerably more oxygen in eighteen hours than the water dilution. The comparative results of all three sets of duplicate experiments showed the same thing.

So far, no explanation of this greater absorption of oxygen by the whitewash dilution has been found that seemed to admit of certain proof. Mr. Winter, of the Division of Chemistry of this Station, has estimated the amounts of sulphur in solution in the water dilution and in the whitewash dilution and found them the same, if taken immediately after making up the dilutions. At that time, also, calcium hydroxide appeared to him to be present in the amount added in making the dilution. After standing for several hours, however, the calcium hydroxide disappeared, as such—the calcium having evidently entered into some other chemical union. The new relation into which this calcium entered was not determined.

*Bulletin 320, N. Y., State Exp. Station.

It was observed that on exposure to the air, the orange color of the polysulphides disappeared more rapidly from the solution diluted with whitewash than from the water dilution.

Mr. Winter's estimations showed, further, that when the two dilutions were exposed to air the polysulphide sulphur in the whitewash dilution decreased a little more rapidly, while the thiosulphate sulphur increased more than in the water dilution. He concluded, therefore, that the polysulphides oxidized on exposure to air a little more rapidly in the whitewash dilution.

If, now, this increased rate of oxidation in the whitewash dilution applies to the thiosulphates as well, it may account, in part at least, for the larger amount of "oxygen used" (Table XIII) in the whitewash dilution; since the oxidation of 2 c. c. of lime-sulphur used there was not entirely complete in eighteen hours. As has already been stated, the polysulphides disappeared early in the experiments and oxygen was used very slowly at the end of the period.

Whitewash added to the lime-sulphur seemed to give body to the spray so that more of it would stick on a given surface. This, also, would seem desirable in orchard spraying, since more of the insecticide would be held in contact with the scales. It may be added that hot lime-sulphur spreads more readily on the bark of a tree than the cold wash, and the heat assists the solution in attacking the wax of the scale.

Whether the addition of excess of lime (as whitewash) to the lime-sulphur and the practice of applying the wash hot would increase the efficiency of this scalecide enough to prove economical in orchard spraying, however, can be decided only by careful practical orchard tests on a large scale. Such tests are out of the province of this project.

GENERAL CONCLUSIONS.

Only general conclusions pertaining directly to the project are given in this summary. Many related considerations of importance outlined or discussed in the body of the paper are not mentioned here.

Usually, contact insecticides do not depend upon one property or means, alone, for their effectiveness, yet as a rule some one property is chiefly concerned.

Alkaline washes, corrosive sublimate solution, and other fluids, which are capable either of dissolving or of precipitating certain constituents of insect-tissues, are able to penetrate the chitin of insects into the tissues slowly. The weaker the surface tension of the fluid, apparently, and the thinner the chitin with which it is in contact the more rapid the penetration. Gases and vapors may penetrate the chitin of insects, especially through the tracheae, into the tissues far more rapidly than liquids.

It is through absorption into the insect-tissues of the volatile portions of kerosene, gasoline, creolin, pyrethrum and such contact insecticides that they mainly become effective agents against insects. Vapors from these insecticides enter the tissues and become effective long before the liquids as such have time to penetrate the chitin. Kero-

sene, miscible oils, etc., are able to enter the spiracles and tracheae of insects even when a "closing apparatus" is present; but the comparatively rapid influence which such insecticides exert does not come from the plugging of the tracheae alone.

The general effects of vapors from gasoline, kerosene, carbon disulphide, creolin and the rest (see page 19) upon insects are very similar to the effects of the vapor of ether. The nervous system seems to be especially affected. Small amounts of such vapors produce, at first, more or less excitement; then a period of uncertain movements; and finally in larger amounts anaesthesia or narcosis. The respiratory activity is usually increased until after the insects become deeply affected, and it is then depressed.

Certain gases and vapors (e. g. sulphur dioxide, ammonia, and hydrocyanic acid gas), when present in respired air continue to be absorbed by insects while they are alive. For the most part, these gases are not given off when the insects are exposed to fresh air but become rather firmly fixed within the tissues.

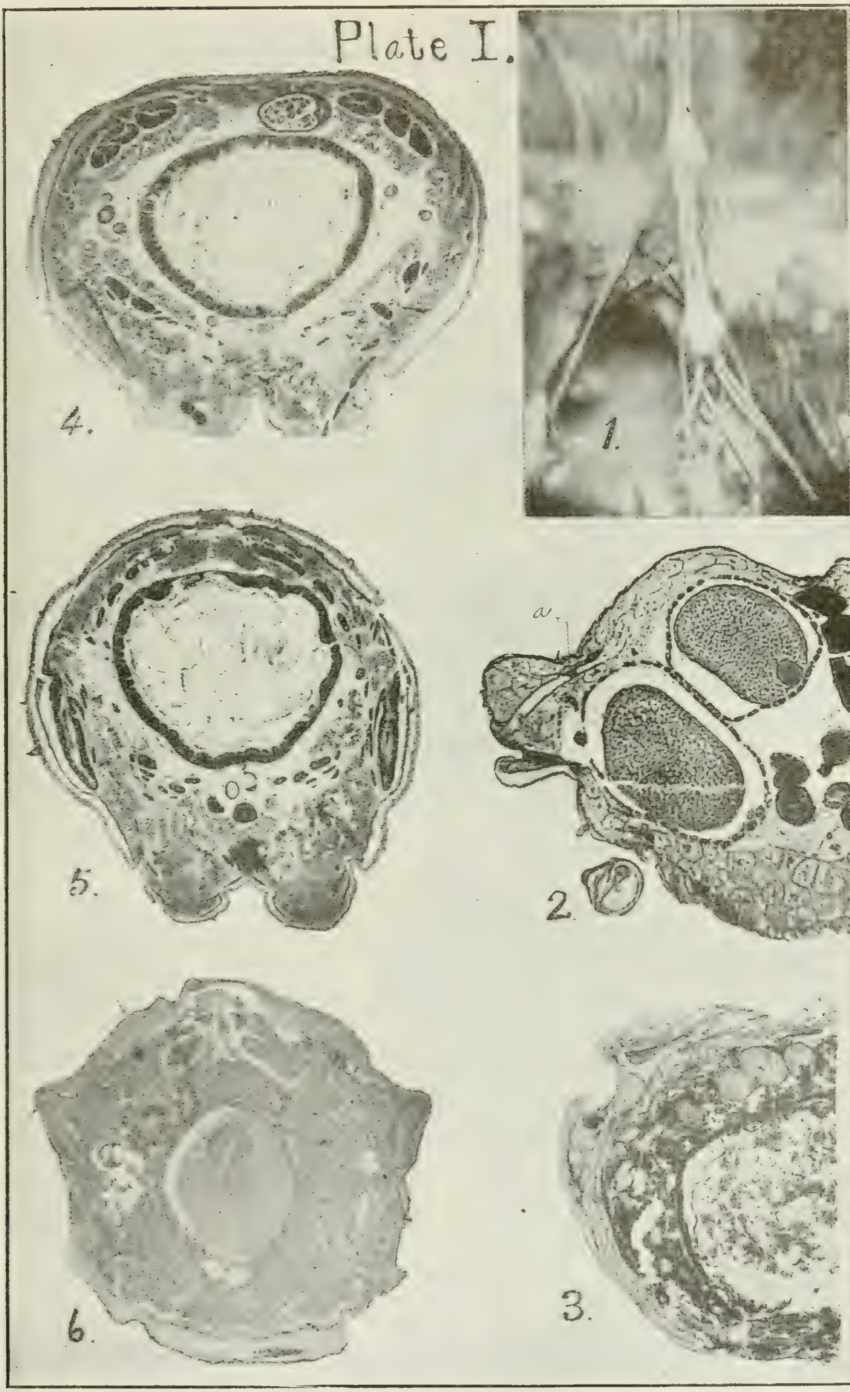
Insect-tissues quickly become saturated with any certain percentage of the vapor of carbon disulphide, carbon dioxide, kerosene, gasoline or similar vapor and no more (at that percentage) is taken up. Then when the insects are exposed to pure air, practically all of such vapors or gases are given off from the tissues again—but not quite as readily as they were absorbed.

Starvation, serious mechanical injury, and ammonia gas were all found to reduce the value of the respiratory quotient below the value given when healthy strong insects are breathing pure air.

The vapors of gasoline, carbon disulphide, kerosene, and To-bak-ine (i. e., Nicotine), when present in sufficient amounts to bring the insects near death, cause the value of the respiratory ratio to rise above the value given by healthy, strong insects breathing pure air—i. e., these vapors depress the activity of oxygen absorption more than they do the carbon dioxide excreting activity. The insects tried could continue to give off small amounts of carbon dioxide when no oxygen was present to be taken up, as when they were kept in tested nitrogen, hydrogen, or carbon dioxide.

The evidence gathered seems to indicate that the vapors of gasoline, kerosene, carbon disulphide and the like, after absorption into the insect-body, become mainly effective through some tendency their presence exerts to prevent oxygen absorption by the tissues.

Lime-sulphur is a special rather than a general contact insecticide. Its strong, persistent reducing power, and its ability to soften the wax about the margin of a scale insect like the San Jose scale are the important properties that make it efficient as a scalecide.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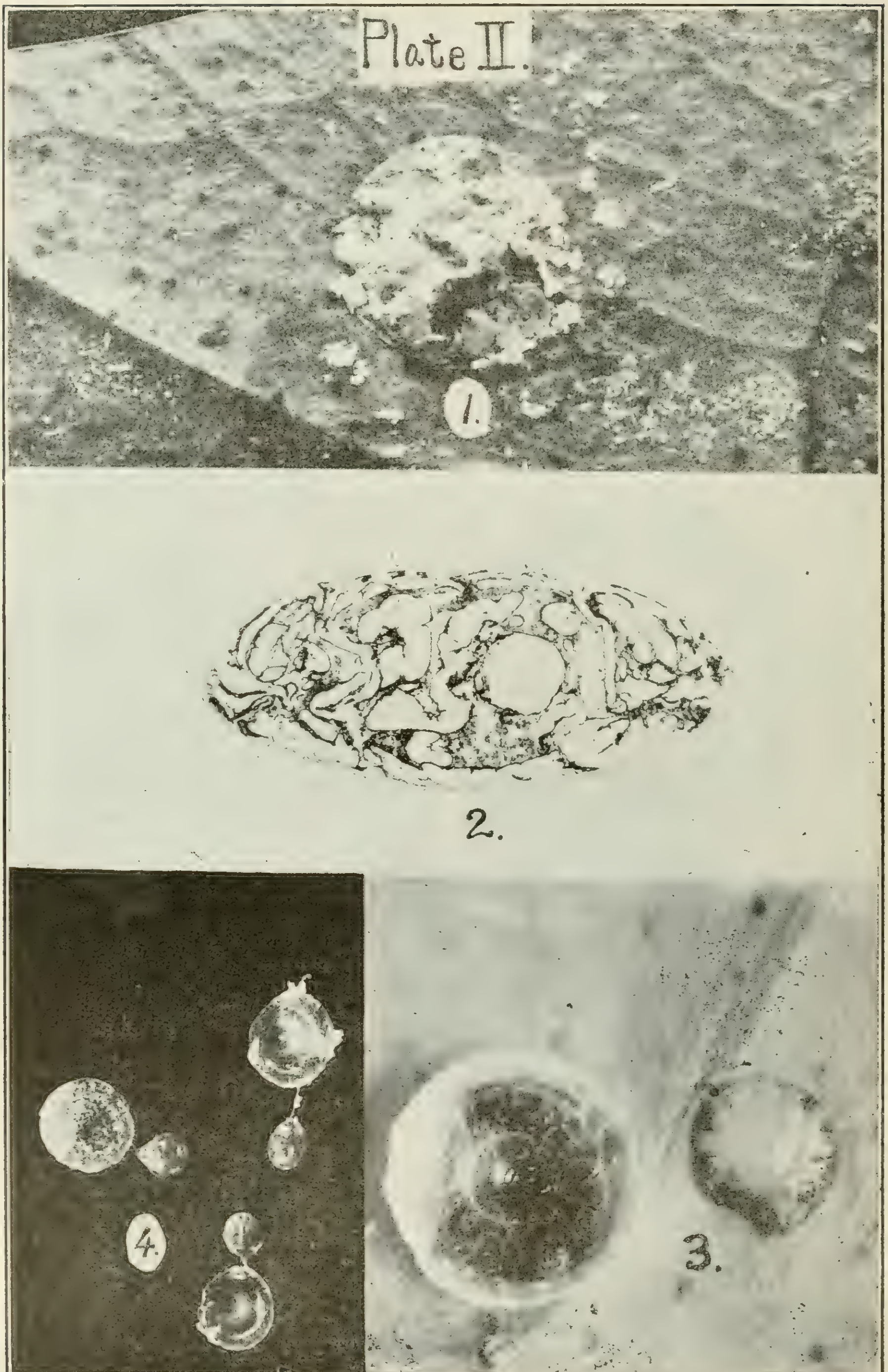
Plate II.
1.
2.
4.
3.

EXPLANATION OF PLATES.

PLATE I.

Fig. 1. Photograph of the last two ganglia of the nervous system of a caterpillar that had been dipped into kerosene stained with Sudan III. Note the tracheae filled with red oil (black in the photograph). After two to three hours *none* of the colored oil had yet passed through the walls of these tracheae.

Fig. 2. Photomicrograph of a cross-section of the abdomen of a Willow-aphid treated with Creolin emulsion containing Indigo Carmine. Fixed with absolute alcohol containing a little picric acid. Note the plug of Indigo Carmine in the trachea at "a." No Indigo Carmine was found in the body except within the tracheae.

Fig. 3. Photomicrograph of a cross-section of a white wood-boring larva that had been first treated with H_2S gas and then immediately injected with hot alcoholic lead acetate solution. Black lead sulphide precipitated. No stain was used on the section.

Fig. 4. Photomicrograph; cross-section of the thorax of a cabbage worm (*Pontia rapae*). No insecticide used. Tissues fixed with hot picric alcohol. Stained slightly with iron haematoxylin.

Fig. 5. Photomicrograph, cross-section of the thorax of a cabbage worm (*P. rapae*) through the wing buds. This larva had been soaked three hours in kerosene. It was then dropped into picric alcohol. Stained slightly with iron haematoxylin.

Note that the tissues are in same condition as in Fig. 4.

Fig. 6. Photomicrograph, cross-section abdomen of cabbage worm (*P. rapae*). Represents the appearance of the tissues in a part of the abdomen treated externally thirty hours with Creolin emulsion. The free untreated part of the body was still able to move (alive) at the end of the period. Dropped into picric alcohol. Stained slightly with iron haematoxylin.

PLATE II.

Fig. 1. Photograph of a (protected from rain) scale of *Aspidiotus* (*Chrysompphalus*) *ficus* on orange; showing the white salts that stooled up in three to four weeks after treatment with a solution of lime-sulphur.

Fig. 2. Photomicrograph, cross-section of a flat wood-boring larva placed in air containing a small percentage of H_2S gas for two hours; then injected *at once* with alcoholic lead acetate as in case of figure 3, Plate 1.

Fig. 3. Photograph of *A. ficus*, on orange made seven days after treatment with lime-sulphur. The dark portion along both margins of the abdomen had blackened in this manner from decay. This portion had been wet with the lime-sulphur, and it showed decay before the rest of the body.

Fig. 4. Photograph, *Aspidiotus* (*Chrysomphalus*) *ficus* six hours after treatment with lime-sulphur. Shows how the wax on the margin of the scale became softened and would sometimes stick to the pygidium so as to pull out into a long thread.

INDEX.

INDEX.

A.

	Page.
Account, current, 1911-1912	18
Account, salaries	20
Accounts for fiscal year ending June 30, 1912, experiment station	19
Accounts for fiscal year ending June 30, 1912, statement of special appropriation	16
Accounts of Michigan Agricultural College	15-24
Account, treasurer's	15
Advisory and assistant staff of experiment station	13
Agricultural College experiment station bulletins	199
Allen, Ruth F., Ph. D., instructor in botany	10
American foul brood	527
Anderson, A. Crosby, B. S., professor of dairy husbandry	7, 13
Annual report of the South Haven experiment station	195
Apple orchards, general treatment for	510
Avian tuberculosis	180

B.

Babcock, Warren, B. S., professor of mathematics	7
Baker, E. C., foreman of foundry	11
Baker, J. Fred, M. F., professor of forestry and supervisor of forest reserve lands	7, 13
Baldwin, Robert J., B. S., executive assistant to dean of agriculture	11
Barrows, Walter B., B. S., professor of zoology and physiology and curator of general museum	7
Beal, William J., Ph. D., D. Sc., emeritus professor of botany	7
Beaumont, John W., member State Board of Agriculture	5
Beighle, Ernest E., B. S., instructor in mathematics	9
Benham, Rachel M., B. S., instructor in bacteriology	10
Bentzen, Frederick W., B. S., instructor in chemistry	10
Berg, Hazel H., A. B., B. S., instructor in domestic art	10
Bessey, Ernst A., Ph. D., professor of botany	8, 13
Betts, Charles D., purchasing agent	11
Birchard, Blanch A., clerk to president	11
Bissell, George W., M. E., dean of engineering and professor of mechanical engineering	7
Bittner, Walton S., B. A., instructor in German and English	10
Blaisdell, Thomas C., Ph. D., professor of English	7
Bock, Joseph C., Ch. E., instructor in chemistry	10
Bogue, Myra V., bulletin clerk	11, 13
Bordeaux mixture	519
Bouyoucos, George J., Ph. D., research assistant in soils	11, 13
Bowd, Edwyn A., College architect	11
Bowditch, John, Jr., instructor in animal husbandry	9
Brown, Addison M., A. B., secretary of college and State Board of Agriculture	5, 7, 13
Brown, Charles W., B. S., assistant in bacteriology	11, 13
Brown, George A., B. S., instructor in animal husbandry	9, 13
Brown, William H., Ph. D., instructor in plant physiology	10
Bulletin No. 265, fertilizer analyses	201
Bulletin No. 266, poultry house construction and yarding	242
Bulletin No. 267, Michigan weeds	269

Page.
Bulletins of the Agricultural College experiment station........................ 199
Burt, Frederick A., B. S., instructor in zoology........................ 9

C.

Casho, Edith W., instructor in physical culture........................ 10
Chamberlain, Frank W., B. S., D. V. M., assistant professor of veterinary science. 8
Chapman, Charles W., A. B., B. S., assistant professor of physics.............. 8
Cherries, general treatment for........................ 513
Church membership of entering class........................ 35
Circular No. 12, tuberculosis in fowls........................ 435
Circular No. 13, winter vetch for a cover crop in Michigan orchards.............. 439
Circular, No. 14, top working apple trees........................ 442
Circular, No. 15, potato culture........................ 445
Circular, No. 16, sandy soils of western and northern Michigan................ 448
Circular, No. 17, the Michigan woodlot........................ 453
Clark, Arthur J., A. B., assistant professor of chemistry........................ 8
Commercial concentrated lime-sulphur wash........................ 517
Committee in charge of experiment station........................ 13
Construction of a silt basin........................ 475
Contract insecticides, for insects that suck........................ 522
Coons, George H., A. M., instructor in plant pathology........................ 10, 13
Copper sulphate solution........................ 520
Counties represented in entering class........................ 34
Crawford, E. C., shop engineer........................ 11
Crawford, Mrs. Harriet B., house director........................ 11
Cron, Lieut. Anton C., professor of military science and tactics.................. 8
Cross, Serg. P. J., instructor in military science and tactics.................. 10
Crowe, Stanley E., B. A., instructor in mathematics........................ 9
Currants and gooseberries, general treatment for........................ 515
Current account, July 1, 1911 to June 30, 1912........................ 18
Curtiss, Charles D., B. S., instructor in civil engineering........................ 11

D.

Data on hog cholera work........................ 151
Davis, Albert H., foreman horticultural department........................ 11
Davis, Benjamin F., treasurer State Board of Agriculture........................ 5
Davis, Royal E., A. B., instructor in zoology........................ 10
Dealers in nursery stock........................ 136
DeZeeuw, Richard, Ph. D., assistant professor of botany........................ 8
Disbursements of experiment station moneys other than received from U. S. Treasurer........................ 149
Disbursements on account of U. S. appropriations........................ 147
Doherty, Alfred J., member of State Board of Agriculture........................ 5
Drainage, lands likely to need........................ 468
Drainage, special bulletin No. 56........................ 467
Drainage, work of practical........................ 484
Dunford, Chas. S., A. M., instructor in economics........................ 11

E.

Effects of certain gases and insecticides upon the activity and respiration of insects........................ 538
Emmons, Lloyd C., B. S., A. B., instructor in mathematics.................. 9
Entering class, church membership of........................ 35
Entering class, counties represented in........................ 34
Entering class, statistics of........................ 34
Establishment of new woods........................ 460
European foul brood........................ 529
Eustace, Harry J., B. S., M. H., professor of horticulture........................ 8, 13
Evans, Ernest A., instructor in mechanical engineering........................ 10
Experiment station accounts for fiscal year ending June 30, 1912.............. 19
Experiment station inventory, summary of........................ 30
Experiment station workers, list of........................ 11

F.

	Page.
Faculty and other officers, Michigan Agricultural College	7
Farmer, Max D., B. S., instructor in drawing	10
Faunce, Benjamin A., clerk to president and editor of M. A. C. Record	11
Fertilizer analyses, bulletin No. 265	201
Fertilizers	445, 452
Financial report, secretary's	15
Fischer, Ernst G., Ph. B., instructor in German	10
Fogle, Floyd E., instructor in farm mechanics	10
Foreign nurseries, list of	137
Foul brood, special bulletin No. 58	526
French, Walter H., M. Pd., professor of agricultural education	8
Freyhofer, Louise B. S., instructor in music	9

G.

General treatment for apple orchards	510
General treatment for cherries	513
General treatment for currants and gooseberries	515
General treatment for grapes	514
General treatment for peaches	510
General treatment for pears	512
General treatment for plums	513
General treatment for potatoes	516
General treatment for raspberries, blackberries and dewberries	515
General treatment for strawberries	516
Gilbert, Ethel M., clerk to secretary	11
Gilchrist, Maude, B. S., A. M., dean of home economics	7
Gilchrist, Norma L., A. B., instructor in English and German	9
Gilson, W. Irving, B. S., instructor in forestry	10
Giltner, Ward, D. V. M., M. S., instructor in veterinary science	9
Graduating class, names of	31-33
Graham, Robert D., chairman State Board of Agriculture	5
Grapes, general treatment for	514
Green manuring	431
Gunson, Thomas, instructor in horticulture and superintendent of grounds	9

H.

Halligan, Charles P., B. S., assistant professor of horticulture	8
Harper, Luella G., clerk to secretary	11
Hartsuch, Bruce E., A. B., instructor in chemistry	11
Hedrick, Wilbur O., M. S., Ph. D., professor of history and economics	7
Hendrick, Mrs. Minnie A. W., A. B., instructor in history and economics	9
Hensel, Herman, A. B., instructor in German and English	9
Hibbard, Rufus, P., Ph. D., instructor in plant physiology	10, 13
Hinman, Clara A., bookkeeper	11
Hobbs, George W., B. S., instructor in mechanical engineering	10
Hog cholera work, data on	151
Holmes, William R., foreman of forge shop	11
Holt, Caroline L., instructor in drawing	9
Home made concentrated lime-sulphur wash	517
Hood, George W., B. S., instructor in horticulture	11
Hoopingarner, Roy G., B. S., instructor in farm crops	10
Hopphan, Karl E., B. S., instructor in mathematics	9
How contact insecticides kill, technical bulletin No. 11	536
How to deal with quack grass	273
Hudson, Ralph S., B. S., farm foreman	11
Hunt, Agnes, B. S., professor of domestic science	8
Huston, Ralph C., M. S., assistant professor of chemistry	8

I.

Income of the Michigan Agricultural College from all outside sources	24
Insects that suck, contact insecticides for	522
Inventory, summary of	25

J.

	Page.
Jeffery, Joseph A., B. S. A., professor of soils and soil physics	7, 13
Johnson, Maurice F., B. S., instructor in mathematics	9

K.

Kedzie, Frank S., M. S., Ph. D., professor of chemistry	7
Kelsall, George A., B. S., instructor in electrical engineering	9
Ketchum, Rowena, nurse in charge of college hospital	11
Killeen, Fred, director of M. A. C. chorus	10
King, E. Sylvester, assistant professor of English	8
Kingman, Edward D., Ph. B., instructor in civil engineering	10
Krentel, Andrew P., foreman of wood shop	11
Kunze, Edward J., B. S., M. E., assistant professor of mechanical engineering	8

L.

Landon, Linda E., librarian	11, 13
Lands likely to need drainage	468
Laycock, William E., instructor in physics	9
Lime-sulphur mixture, self boiled	518
Lime-sulphur wash, commercial concentrated	517
Lime-sulphur wash, home made concentrated	517
Linton, John O., B. S., instructor in poultry husbandry	10
List of foreign nurseries	137
List of licensed Michigan nurseries	134
List of standing committees	5
Lodge, W. Lloyd, B. S., M. A., assistant professor of physics	8
Lyman, Richard P., B. S., M. D. V., dean of verterinary science; professor of veterinary medicine	8

M.

Macklin, John F., professor of physical culture and director of athletics	8
Marsh, Herbert E., B. S., instructor in civil engineering	9
Marshall, Charles E., Ph. D., professor of bacteriology and hygiene	7, 13
Marti, William C., B. S., assistant in chemistry	11, 13
Mayne, Louis B., A. B., instructor in English	10
McDaniel, Eugenia I., A. B., instructor in entomology	10
McDaniel, John S., B. Sc., D. V. S., assistant professor of veterinary surgery	8
Meech, Maud A., chief clerk to secretary	11
Melick, Cyrus A., D. C. E., assistant professor of civil engineering	8
Members of standing committees	5
Members of State Board of Agriculture	5
Members of Station Council	13
Meteorological tables	113-130
Michaelides, Helen I., instructor in French and English	8
Michigan Agricultural College, accounts of	15-24
Michigan Agricultural College, faculty and other officers of	7
Michigan Agricultural College, income from all outside sources	24
Michigan nurseries, list of licensed	134
Michigan weeds, bulletin No. 267	269
Mitchell, John R., A. B., instructor in chemistry	10
Morris, Harold H., A. B., instructor in chemistry	10
Morse, James L., instructor in mechanical engineering	10
Musselman, Harry H., B. S., instructor in farm mechanics	9
Myers, Jesse J., B. S., assistant professor of zoology	8

N.

Names of graduating class	31-33
Neal, John A., assistant in machine shop	11
Newell, Lory F., engineer	11
Newhall, Harold, W. F., B. S. A., instructor in dairying	10
Newman, Chace, assistant professor of drawing and design	8

	Page.
New woods, establishment of	460
Northrup, L. Zae, B. S., instructor in bacteriology	9
Nursery stock, dealers in	136

O.

Ockerblad, Andrew M., B. S., in C. E., instructor in civil engineering	10
Osler, Harold S., B. S., instructor in zoology	9
Other states and counties represented	34

P.

Palm, Elizabeth M., B. S., assistant librarian	11
Patten, Andrew J., B. S., chemist of experiment station	11, 13
Peaches, general treatment for	510
Peach yellows and little peach	511
Pears, general treatment for	512
Penny, Raymond D., instructor in English	10
Peppard, Mrs. Lillian L., instructor in domestic art and domestic science	9
Pettit, Rufus H., B. S. in Agriculture, professor of entomology	7, 13
Plums, general treatment for	513
Poisons used in spraying	521
Polson, Joseph A., B. S., assistant professor of mechanical engineering	8
Positions and salaries as shown by pay roll dated June 30, 1912	20-23
Potato culture, circular No. 15	445
Potaoes, general treatment for	516
Potts, A. R., field agent soils and crops	11
Poultry house construction and yarding, bulletin No. 266	242
Powell, Ralph W., B. S., instructor in civil engineering	10
Preparation of spray mixtures	516
Present condition of woodlots	453

Q.

Quack grass, how to deal with	273

R.

Rahn, Otto, Ph. D., assistant professor of bacteriology	8-13
Raspberries, blackberries and dewberries, general treatment for	515
Raven, W. F., live stock field agent	11
Reece, Richard H., B. S., instructor in mathematics	10
Report of secretary of the State Board of Agriculture	3
Report of the bacteriologist, of experiment station	151
Report of the botanist of experiment station	192
Report of the chemist of experiment station	187
Report of the dean of agriculture	37
Report of the dean of engineering	60
Report of the dean of home economics	72
Report of the dean of veterinary division	74
Report of the department of agricultural education	55
Report of the department of animal husbandry	43
Report of the department of bacteriology and hygiene	78
Report of the department of botany	79
Report of the department of chemistry	82
Report of the department of civil engineering	64
Report of the department of dairy husbandry	42
Report of the department of drawing and design	70
Report of the department of English and modern languages	89
Report of the department of entomology	95
Report of the department of farm crops	44
Report of the department of forestry	47
Report of the department of history and economics	96
Report of the department of horticulture and landscape gardening	40
Report of the department of mathematics	102

	Page.
Report of the department of mechanical engineering	61
Report of the department of meteorology	109
Report of the department of military science	106
Report of the department of physics and electrical engineering	68
Report of the department of poultry husbandry	45
Report of the department of soils	45
Report of the department of zoology and physiology	107
Report of the director of the experiment station	149
Report of the entomologist of the experiment station	193
Report of the experiment station of Michigan Agricultural College	145
Report of the farm crops experimenter, experiment station	189
Report of the horticulturist of experiment station	194
Report of the librarian	99
Report of the Michigan weather service	131
Report of the president	31
Report of the secretary and treasurer of experiment station	147
Report of the soil physicist, experiment station	191
Report of the state inspector of nurseries and orchards	132
Report of the superintendent of farmers' insti utes	138
Report of work as state veterinarian	182
Robbins, Warren S., assistant in bacteriology	11
Robertson, James E., B. S., instructor in mathematics	9
Robinson, Charles S., M. S., research assistant in chemistry	11, 13
Robinson, William A., A. B., S. T. B., instructor in English	9
Robson, Antoinette A., instructor in German and English	9
Roseboom, Benjamin B. Jr., B. S., instructor in zoology	9
Round-up institute	142
Ryder, Edward H., M. A., associate professor of history and economics	8

S.

Sanford, F. Hobart, B. S., assistant professor of forestry	8
Sawyer, Arthur R., B. S., E. E., professor of physics and electrical engineering	7
Sayer scholarship fund, William Smith	17
Scale insects, some properties of lime-sulphur wash that make it effective in killing	583
Schepers, Jacob, cashier	11
Schneider, C. F., director of U. S. weather service	13
Scholarship fund, William Smith Sayer	17
Scott, Grace L., instructor in music	10
Secretary and treasurer of experiment station, report of	147
Secretary's financial report	15
Seeley, Dewey A., B. S., instructor in meteorology	10
Self boiled lime sulphur mixture	518
Shafer, George D., Ph. D., instructor in entomology	9, 13
Shaw, Robert S., B. S. A., dean of agriculture and director of experiment station	7, 13
Shoesmith, Vernon M., B. S., professor of farm crops	8, 13
Silt basins	474
Silt basins, construction of	475
Simpson, Milton, M. A., instructor in English	10
Smith, Arthur S., instructor in mechanical engineering	10
Snelgrove, Isabel P., instructor in drawing	9
Snepp, Hugh A., B. S., instructor in mathematics	9
Snow, Oren L., B. S., instructor in physics	10
Snyder, Jonathan L., A. M., Ph. D., L. L. D., president of Michigan Agricultural College	5, 7, 13
Soils of western and northern Michigan, circular No. 16	448
Some properties of lime-sulphur wash that make it effective in killing scale insects	583
South Haven experiment station, annual report of	195
Special appropriation accounts for fiscal year ending June 30, 1912	16
Special bulletin No. 56, drainage	467
Special bulletin No. 57, spraying	510
Special bulletin No. 58, foul brood	526
Species and soils	462
Spragg, Frank A., M. S., assistant in crops	11

	Page.
Spraying, poisons used in	521
Spraying, special bulletin No. 57	510
Spraying with chemicals	274
Spray mixture, preparation of	516
Spurway, Charles H., B. S., instructor in soil physics	9
Standing committee in charge of experiment station	13
Standing committees, members of	5
State Board of Agriculture, members of	5
State Board of Agriculture, report of secretary of	3
State cooperative woodlot work	466
State veterinarian, report of work as	182
Station Council, members of	13
Statistics of entering class	34
Stevens, Grace E., A. B., instructor in domestic science	10
Strawberries, general treatment for	516
Summary of inventory	25, 30
Summary of students	35

T.

Taft, Levi R., M. S., superintendent of farmers' institutes and state inspector of orchards and nurseries	7
Taylor, Rose M., A. B., instructor in botany	8
Technical bulletin No. 11, how contact insecticides kill	537
The Michigan woodlot	453
Thompson, Bertha E., A. B., instructor in botany	10
Tile	469
Tile systems	469
Top working apple trees, circular No. 14	442
Treasurer's account	15
Tuberculosis, avian	180
Tuberculosis in fowls, circular No. 12	435
Twenty-fifth annual report of the experiment station	145

U.

United States appropriations, disbursements on account of	147
Uphof, Johannis C. Th., in charge of botanic garden	11

V.

Van Suchtelen, F. H., Ph. D., research assistant in bacteriology	11
Vedder, Herman K., C. E., professor of civil engineering	7

W.

Wallace, William H., member State Board of Agriculture	5
Walsworth, Louise E., clerk to secretary	11
Waterbury, I. Roy, member State Board of Agriculture	5
Watt, A., instructor in blacksmithing	9
Weed seeds oftenest met with in clover seed	272
Wendt, Wylie B., B. C. E., assistant professor of civil engineering	8
When the codling-moth flies	524
White, O. K., B. S., horticultural field agent	11
Wilson, Victor T., M. E., professor of drawing and design	8
Winter vetch for a cover crop in Michigan orchards, circular No. 13	439
Woodlots, present condition of	453
Woodlot work, state co-operative	466
Woodman, Jason, member State Board of Agriculture	5
Work of practical drainage	484
Wright, Luther L., ex-officio member State Board of Agriculture	5

Y.

Yakeley, Elida, registrar of College	7